

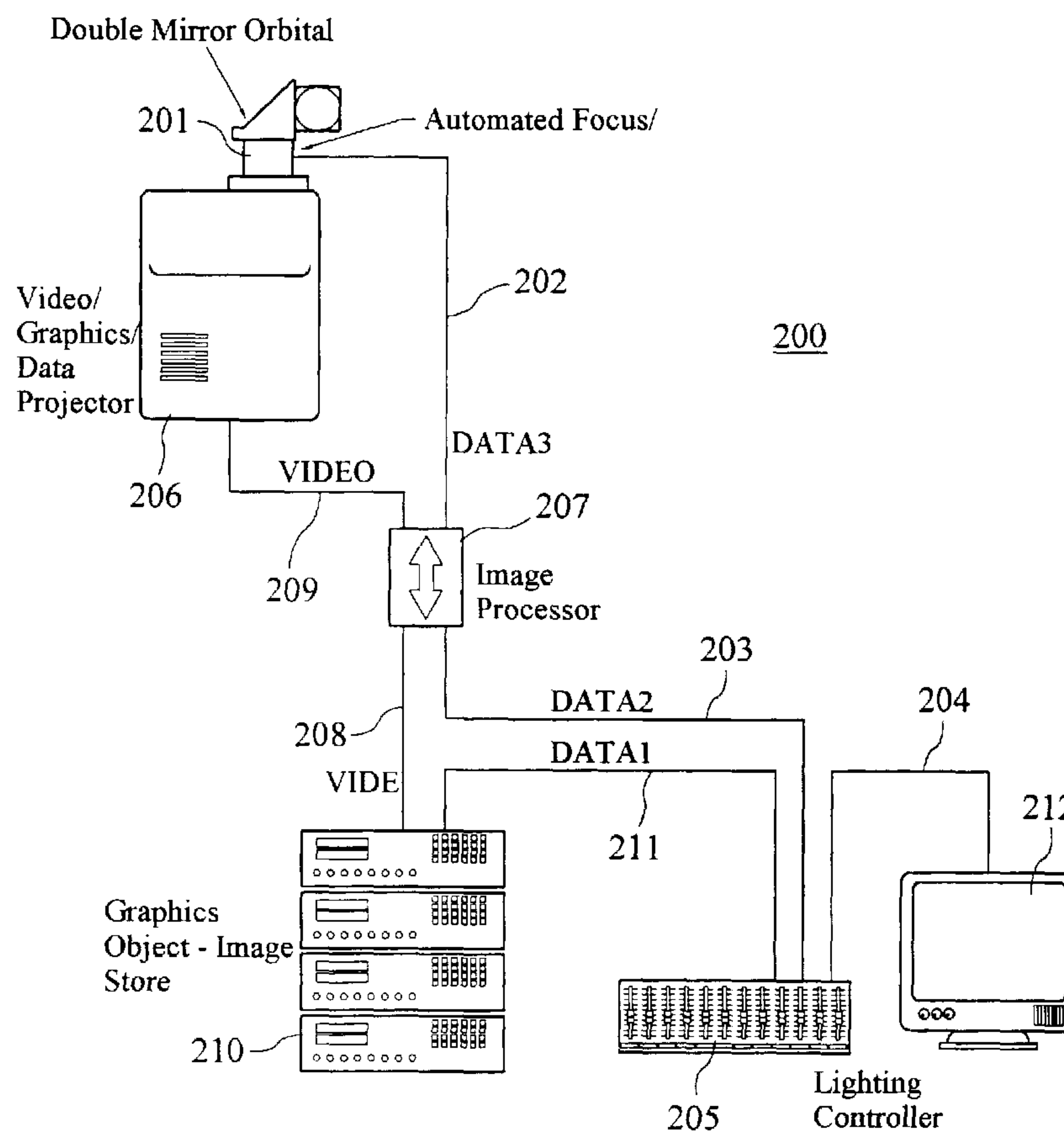


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(54) Titre : PROJECTEUR D'IMAGES

(54) Title: IMAGE PROJECTION APPARATUS



(57) Abrégé/Abstract:

In creating visual effects with lighting apparatus, a digital image projector is adapted to receive digital image information and to project an image beam, a beam director directs the image beam in a plurality of directions over the set and an image processor processes the digital image information in accordance with the direction of the beam.



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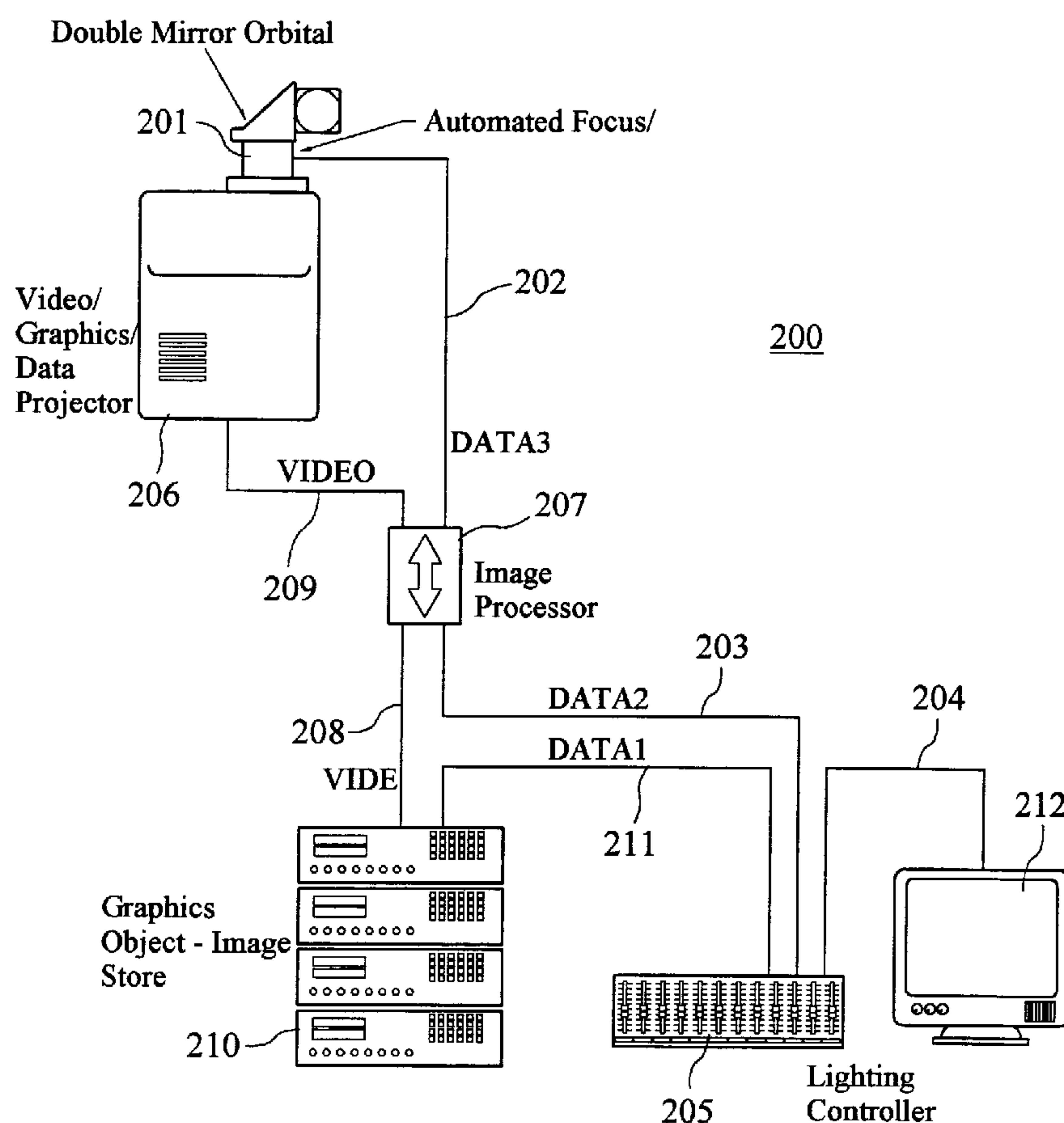
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(54) Title: IMAGE PROJECTION APPARATUS



(57) Abstract: In creating visual effects with lighting apparatus, a digital image projector is adapted to receive digital image information and to project an image beam, a beam director directs the image beam in a plurality of directions over the set and an image processor processes the digital image information in accordance with the direction of the beam.

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IMAGE PROJECTION APPARATUS

This invention relates to image projection apparatus and in particular aspects, to lighting apparatus for use in conjunction with image projection apparatus, still
5 more particularly to apparatus for projecting dynamic images.

In the entertainment lighting industry, a wide range of apparatus are known for creating lighting effects with both static and movable and controllable spotlights and there are a host of devices for altering the output of these lights; these
10 devices include diffusers, gobos and coloured glass and plastic filters. Video and slide projectors are also increasingly used to enhance the range of techniques available to designers of entertainment, promotion, advertising and corporate presentations.

15 WO 98/18040 describes a light projector and associated methods of achieving various effects.

A projector based upon an array of digital micromirrors is made by Texas Instruments Inc., of Dallas, Texas, USA, and US patent 5828485 describes
20 uses of such a projector in obtaining gobo effects.

A further device is known from WO 98/18037 in which a beam is reflected from a mirror and an image generator is moved in tandem with movement of the mirror so as to correct for distortion caused by the movement of the mirror.
25

Designers at the current time seek ever to introduce further innovation in the effects they achieve through new combinations of existing equipment and faster and more accurate control of that equipment.

30 The present invention seeks to provide and open up a new field of light and image projection, both using static and dynamic images, and thus including video projection as well as stage and other lighting effects.

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Accordingly, the present invention provides, in a first aspect, lighting apparatus for creating lighting effects in a set, comprising a digital image projector adapted to receive digital image information and to project an image beam; a
5 beam director serving to direct the image beam in a plurality of directions over the set; and an image processor serving to process the digital image information in accordance with the direction of the beam.

In this manner, the invention allows a variety of static and dynamic effects to be
10 created. Preferably, the image processor serves to correct for image distortions arising from incidence of the image beam upon surfaces in the set which are not orthogonal to the beam. Thus, the system allows effects to be created on a variety of surfaces, and from a variety of orientations. Advantageously, the beam director comprises a beam deflector and the image processor corrects for
15 image distortion introduced by the deflector. Suitably, the processor corrects for rotation of the image, and advantageously, for inversion of the image. In certain embodiments, the processor corrects for distortion caused by variation in focus. In other embodiments, the processor corrects for distortion caused by variation in zoom. In this manner, the apparatus may correct for a number of distortions
20 in the image projected, whether caused by deflection or by the characteristics of the projection surface.

The system of the invention thus enables a wide variety of effects to be achieved using known video projection equipment, effects not envisaged or
25 imagined in design of the projectors. Projectors can be used dynamically to project images onto different viewing surfaces, switching from surface to surface and scanning images across surfaces whilst the apparatus continuously corrects for image distortions caused by movement of the deflector, and by changes encountered in the . Still and moving images can be
30 moved like scenery without the need for heavy staging equipment.

Suitably, the digital image processing corresponds to rotation of at least part of

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the image through a rotation angle about at least one axis of rotation. More suitably, the axis of rotation and the rotation angle are determined from the instantaneous orientation relative to the beam of that surface of the set upon which the beam is incident.

5

In an embodiment, the apparatus further comprises a data store for storing a model of the set, said instantaneous orientation being determined through reference to said model. Suitably, the apparatus further comprises scanning means for mapping surfaces of the set to derive said model. Advantageously, the apparatus further comprises a user interface for deriving said model. Preferably, the apparatus further comprises measuring means for measuring said instantaneous orientation.

10

Advantageously, the image processor is adapted to process differentially respective image regions. Suitably, said image regions correspond respectively with multiple surfaces of the set upon which the beam is simultaneously incident.

15

Preferably, the beam director comprises first and second moveable reflectors, the light beam being deflectable by the first reflector on to the second reflector so as to deflect the beam in said plurality of directions.

20

Suitably, the digital image information represents moving images and the digital image processor operates in real time.

25

In a further aspect, the invention consists in a method of creating lighting effects in a set, comprising the steps of directing an image beam from a digital image projector adapted to receive digital image in a plurality of directions over the set; and processing the digital image information in accordance with the direction of the beam.

30

Preferably, the image processing serves to correct for image distortions arising

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from incidence of the image beam upon surfaces in the set which are not orthogonal to the beam.

Suitably, the image processing corrects for distortion caused by variation in
5 focus. In an embodiment, the image processing corrects for distortion caused
by variation in zoom. In another embodiment, the digital image processing
corresponds to rotation of at least part of the image through a rotation angle
about at least one axis of rotation. Preferably, the axis of rotation and the
rotation angle are determined from the instantaneous orientation relative to the
10 beam of that surface of the set upon which the beam is incident. Suitably, said
instantaneous orientation is determined through reference to a digital model of
the set.

Advantageously, the image processing serves to process differentially
15 respective image regions. Suitably, said image regions correspond respectively
with multiple surfaces of the set upon which the beam is simultaneously
incident. Advantageously, the digital image information represents moving
images and the digital image processing operates in real time.

20 In another aspect, the invention consists in lighting apparatus for creating
lighting effects in a set, comprising digital image projection means for receiving
digital image information and projecting multiple image beams; means for
deriving the relative orientation of the set and the image beams; and image
processing means for processing the digital image information in accordance
25 with the derived orientation.

Preferably, the image processing means serves to correct for image distortions
arising from incidence of the image beam upon surfaces in the set which are
not orthogonal to the beam.

30

Suitably, the apparatus further comprises means for directing in a plurality of
directions the beam of each image projection means. This permits the direction

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of each image beam onto a variety of areas of the set.

Advantageously, the apparatus further comprises a plurality of image beams projected from different and substantially spaced points. Suitably, the image
5 beams fall on substantially the same point on the set. This allows the creation of further lighting effects, such as eliminating the shadow cast by the set and the image beam from a single projector.

More suitably, the image processing means is adapted to process the image
10 information differentially for projection of respective image beams. Thus further effects may be created whereby different areas of a set may be illuminated from different angles, by different images, creating a single effect at a point on the set.

15 In a further aspect, the invention consists in a method of creating lighting effects in a set, comprising the steps of projecting multiple image beams from respective digital image projection means adapted to receive digital image information; deriving a relative orientation between the image projection means and a set; and using the orientation in processing the digital image information,
20 in order to provide a lighting effect.

Preferably, the step of processing serves to correct for image distortions arising from incidence of the image beam upon surfaces in the set which are not
orthogonal to the beam.

25

Suitably, the method comprises projecting a plurality of image beams from different points. Advantageously, the image beams fall on substantially the same point on the set. More advantageously, the method comprises processing the image information differently for projection on distinct image beams.

30

In still another aspect, the invention consists in lighting apparatus, comprising:-

- a deflector to deflect a light beam in a plurality of directions;

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- image processing means to process image information, comprising an input to receive raw image information, a processor to process the raw image information into processed image information, and an output to output processed image information; and
- 5 - a controller that controls operation of the processor of the image processing means according to the status of the deflector.

This apparatus is especially useful in combination with a video projector and an image source, designed for static projection of an image onto a viewing
10 surface. In operation of one such known projector, data in an image source such as a graphics store is fed to the projector input, processed by the projector to form a projection beam and then projected. Focus and zoom controls are included on the projector as per usual. Using a personal computer (PC), or other graphics engine, an extensive range of images can be produced. The
15 graphics store is typically in memory in or adjacent the projector or remote from the projector, and used to store imagery, such as artwork, an image library, static and moving images, vector and bit map images, base-band video, streamed video in compressed formats, data output from a PC and the like. Suitable storage includes floppy disk, optical disk, DVD, mini-disk, videotape, or
20 any other appropriate digital storage medium

The present invention provides apparatus optionally in modular or kit form that modifies or updates existing video projection systems. The apparatus suitably has connections so as to intercept the data output from the graphics store, that
25 is to say the input signal to the projector, optionally further process that data and then pass the data on to the projector. The apparatus includes a deflector which is positioned so as to deflect the light beam output from the projector. The deflector may as a side effect of deflecting the beam impart distortion to the image when its direction of projection is altered. The function of the image
30 processor is to introduce a correction to the image data in anticipation of the distortion that occurs as a result of passing through the deflector. The function of the processor is optional in as much as the correction can be turned off or on

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according to the type of effect wanted. It is in addition optional to use the image processor deliberately to distort the image and/or to superimpose further and different effects upon the raw or corrected data. With knowledge of the video image desired to be seen on the viewing surface, the controller can direct
5 appropriate processing by the processor according to the status of the deflector.

The image processing means can comprises a first memory to store the raw image information and a second memory to store the processed image
10 information. The contents of the second memory are then used for generation of the image by, for example, a projector.

In use, the deflector rotates an image in the projection beam as a consequence of deflecting the beam, and a function of the controller is to direct the processor
15 to process the raw image information so as to provide a correction therefor in the processed image information. It is an advantage that as a result the projected video image can therefore remain upright.

It may further be necessary to correct keystoneing of the image, introduced e.g.
20 by a tilted single mirror or by the projection beam striking the screen at an angle, and a suitable correction may be achieved using a pair of prisms or a moveable lens which enable horizontal and vertical keystone to be corrected independently. Alternatively, keystoneing maybe corrected by adjusting the image during or after image generation. Hence, it is further preferred that the
25 apparatus is arranged such that when the deflector introduces a keystone effect into an image in the light beam the controller directs the processor to process the raw image information so as to provide a correction therefor in the processed image information. In apparatus that is especially preferred, there is provided the option that when the deflector both rotates an image in and
30 introduces a keystone effect into an image in the light beam the controller directs the processor to process the raw image information so as to provide corrections for both distortions in the processed image information. In this way

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these two separate distortions are dealt with.

A particular apparatus of the invention also has means to correct the focus according to the direction of projection, and this correction is optionally
5 achieved by moving an objective lens of the image projector. The correction may be calculated with reference to the distance from the image projector to the surface, and this distance may be measured using a distance detector such as an electronic range-finding device utilising the Doppler-shift effect, with a sensor mounted on the image projector. The focus correction may also be
10 known from calibration of the equipment and pre-programmed so that when the deflectors of the apparatus are directed to deflect the beam in a given direction the distance to the viewing surface is known and the required focus adjusted according to a look-up table or similar. As will be appreciated by those in this art, the focusing means may be located in the path of the light beam between
15 the projector and first light deflection means. Alternatively, the focusing means may be located in path of the light beam between the first and second light deflection means. As another alternative, the focusing means may be located in the path of the light beam to focus the image deflected by the second light deflection means. In a further alternative, the focusing means adjusted is the
20 projector itself, or that portion of the projector which substantially deflects the beam. The processor can thus be programmed in software so as to direct the status of the focusing means according to the status of the deflector. The controller may also direct the status of the focusing means according to the distance along the beam from the apparatus to a viewing surface. This enables
25 dynamic changes in focus, through continuous feedback from a distance finder associated with the apparatus to the controller followed by output of an appropriate focusing signal, either to its own focusing means or to that of the projector, whilst the output of the projector is moved from one viewing surface to another. In still another embodiment, the focusing is adjusted by means of
30 manipulation of the raw image information by the processor in order to achieve the required focusing.

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Similarly, the apparatus can further comprise zoom control means, with the controller directing the status of the zoom control means according to the status of the deflector or the distance along the beam from the apparatus to a viewing surface. As with focus information, zoom signals can be output to zoom
5 equipment of the apparatus or to external zoom equipment such as on a projector e.g. to maintain the desired image size or introduce special effects. In an alternative, the zoom is adjusted by means of manipulation of the raw image information by the processor in order to correct the distortion perceived. An advantage of this process is that the diameter of the beam may be maintained,
10 as the correction is performed in the image domain.

Preferably, the deflector has two moveable deflectors, mirrors are particularly suitable, so that the beam can be reflected in substantially any direction according to the respective positions of the mirrors. In apparatus described
15 below in more detail, there is a first light deflection means arranged to rotate about a first axis and a second light deflection means arranged to rotate about a second axis substantially orthogonal to the first axis, and this is sometimes referred to as a double mirror head. An advantage of a double-mirror type deflector is that the image remains orthogonal after being deflected, simplifying
20 the correction(s) needed by the image processor e.g. to keep the image upright and free of keystone. The first and/or second light deflection means may also comprise first or second rotatable lenses, prisms, interferometric mirrors, fibre optics, or other forms of deflectors.

25 For ready use of the lighting apparatus with a projector, the apparatus can also include coupling means for securely coupling the lighting apparatus to a projector in such a position that the light beam output from the projector passes through the deflector of the lighting apparatus and so that the output of the image processing means of the lighting apparatus can be coupled to an input
30 on the projector that receives image information of an image to be projected. The joining of a projector to this apparatus provides a system for light projection that greatly increases the uses and versatility of known projectors, providing a

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system with capabilities well beyond anything envisaged for a static projector. Inputs to the image processor and video projector are suitably in accordance with the DVI protocol.

5 Apparatus of a further aspect comprises:-

- a deflector to deflect a projection beam in a plurality of directions;
- beam correction means to impart rotation of an image in the beam; and
- a controller that directs the degree of rotation imparted by the beam correction means according to the status of the deflector.

10

Image processing means can be included, to process image information, said image processing means comprising an input to receive raw image information, a processor to process the raw image information into processed image information, and an output to output processed image information, wherein the
15 deflector introduces a keystone effect into the image and the controller directs the image processing means to process the raw image information so as to provide a correction for that keystone effect in the processed image information. In this way, there is mechanical rotation correction and software keystone correction.

20

Again, focusing means can be incorporated into the apparatus so the controller directs the status of the focusing means according to the status of the deflector, or the controller can comprise an output for outputting focus information to a projector, and the apparatus can include zoom control means and the controller
25 directs the status of the zoom control means according to the status of the deflector, or the controller comprises an output for outputting zoom control information to a projector according to the status of the deflector.

30

A still further aspect of the invention provides apparatus in which the elements described above are incorporated into one apparatus rather than by combining together of various individual units. Projection apparatus of this aspect accordingly comprises:-

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- image processing means to process image information and comprising an input to receive raw image information, a processor to process the raw image information into processed image information, and an output to output processed image information;

5 - a beam generator to generate a light beam from the processed image information;

- a deflector to deflect the light beam in a plurality of directions; and

- a controller that controls operation of the processor of the image processing means according to the status of the deflector.

10

Optional and preferred features of the apparatus of the previous two aspects, related to image processing, deflector(s), controller, focus control and focusing means, zoom control and zoom means, distance detection and others are similarly optional and preferred features of apparatus of this aspect.

15

A further aspect provides light projection apparatus in which rotation correction is mechanical, and comprising:-

- a beam generator to generate a light beam

- a beam correction means to impart rotation of an image in the beam; -

20 a deflector to deflect the light beam in a plurality of directions; and

- a controller that controls the rotation imparted by the beam correction means according to the status of the deflector.

Optional and preferred features of the apparatus of the above aspects, related
25 to image processing, deflector(s), controller, focus control and focusing means, zoom control and zoom means, distance detection and others are similarly optional and preferred features of apparatus of this aspect.

A still further aspect of the invention provides a method of projecting an image
30 in a light beam, comprising:-

- generating the light beam;

- deflecting the light beam of a deflector, the deflector being moveable

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so as to deflect the beam in a plurality of directions, an effect of deflecting the beam being to rotate the beam; and

- prior to deflecting the beam, imparting a rotation of the beam to correct for the rotation caused by deflecting the beam.

5

An effect of deflecting the beam can be to change the distance from the deflector to a surface on which the image is viewed, and the method preferably comprises adjusting the focus of the beam according to the change in distance.

10 A further effect of deflecting the beam can be to change the distance from the deflector to a surface on which the image is viewed, wherein the method preferably comprises adjusting the zoom of the beam according to the change in distance to maintain the image size on the screen. A still further effect of deflecting the beam can be to introduce a keystone effect into an image in the beam, wherein the method preferably comprises, prior to deflecting the beam,
15 introducing a correction to the keystone imparted by the deflecting of the beam.

References to a projector are intended to include reference to projectors that include lenses and optical elements, projection engine components the output of which may be electrical. Suitable projectors may include cathode ray tubes,
20 light valve technology, the Texas Instruments Inc. DLP (registered trade mark) projection engine relying upon a DMD (digital micro mirror, registered trade mark) chip, liquid crystal devices such as polysilicon LCD panels (P-Si), optionally with Micro-Lens arrays or other reflective LCD devices such as JVC's direct drive light amplifier (D-ILA).

25

Using the apparatus described, an image can be projected against a concave surface, such as the inside of a sphere in a specially designed viewing area with location for spectators proximal to the projector.

30 The apparatus can also be used to project an image onto a stage, such as a theatre stage, moving the deflector so as to move the image about the stage. One example of the invention in action comprises moving the beam so that it

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follows an actor as he or she moves about. A scene representing movement of an actor, say, in a car is readily achieved with projection of a static or moving background onto and around the actor; as the actor moves across the stage so the background may also follow the actor, resulting in a new and visually
5 pleasing effect not achievable hitherto.

Another example of the invention in action comprises using apparatus to project an image onto the stage at a predetermined position, thereafter turning off the projecting means, or dimming or obscuring the output, moving the deflector and
10 thereafter projecting an image, optionally a different one, at a second predetermined position. Use of the invention in this way reduces the need for separate lights for the separate images, or reduces the need for manual adjustments between projecting first and second images, offering a significant increase in flexibility for the operator. With the present invention it is possible to
15 create effects that are quite different from and go far beyond presently available effects, in that dynamic video images can be projected onto and around, say, individuals on stage and tracked across the stage or across the viewing surface without distortion of the image. It is further possible to fade, rotate, shift or morph from one image to another, for example with one image superimposed
20 on another for a part of the time between changing from one image to the next - all effects not achievable using known apparatus.

The present invention aims to provide novel means for moving an image over a surface and adjusting that image according to how it is moved over the surface,
25 allowing for rotation, keystone, focus and zoom effects. Preferably, the lighting apparatus comprises first and second rotatable light deflection means for deflecting a light beam in different directions, the beam being deflectable by the first light deflection means on to the second light deflection means so as to deflect the beam in substantially any direction. Thus, for example, a double
30 mirror-containing head is used to direct the beam in any direction, at the control of the operator. Data feedback from the head as to the relative positions of the mirrors can be used to calculate and control the degree to which a correcting

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rotation and/or keystone is introduced into the image. Alternatively, the head can be instructed to direct the beam in a given direction and knowledge of that direction and the resultant correction required can be used to control the degree of correction to be made.

5

By providing separate image rotation means, the degree of rotation of the image can be carefully controlled, and effects as described in more detail below achieved.

10 In particular, the apparatus may be used to project an image contained in the light beam in many directions. An image producing device, referred to sometimes as the object, may be placed in the optical path to shape the light beam produced by the light source, or a video image may be projected. As the pan and tilt in the double mirror head are rotated, the image projected by the
15 apparatus moves spatially. However, if the image is projected, for example, horizontally and swept about a vertical axis, without a compensating rotation of the image by the image rotation means (the processor or the beam correction means) the projected image will appear to rotate about the longitudinal axis of the beam. This would be problematic when the image is asymmetrical; for
20 example, if the projected image is a face, the face would appear to rotate with the sweeping of the light beam. The present invention thus avoids this unwanted problem.

Preferably, the apparatus further comprises control means for controlling the
25 rate of rotation of the image by the image rotation means. The control means may be arranged to calculate a required rate of rotation of the image by the image rotation means from the rate of rotation of each of the first and second light deflection means.

30 In a preferred embodiment, rotation of the image in one direction by the image rotation means is adapted to compensate for rotation of the image in the other direction due to deflection thereof by the first and second light deflection

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means. This can enable an asymmetric image to be swept by 360 by 360 degrees (global projection) with substantially no rotation of the image about the longitudinal axis of the beam, rotation of the image due to deflection thereof by the first and second light deflection means being automatically compensated by rotation of the image rotation means.

In use of the present invention, an asymmetric image, for example a video image, is moved over a viewing surface without rotation of the image perceived by the spectator. As a spectator watches, the image remains in an upright orientation. In addition to, or as an alternative to, eliminating any rotation of the image, the image rotation means may be arranged to introduce a desired rotation of the image. This can produce spectacular optical effects; for example, the projected image can be swept through a given angle and onto different angled surfaces at different distances from the object projector with substantially no rotation thereof, and then rotated through any chosen angle whilst the mirrors in the head remain still.

To maintain an image upright as it moves across a surface, the rotation of the image rotation means needed to compensate for rotation of the image due to deflection off the deflectors may be calculated from the respective movements of the first and second light deflection means. Alternatively, using appropriate software, the compensating rotation may be obtained from a pre-calculated look-up table. Another option is to use a correction as described in WO 98/18037. One mechanical option is that the image rotation means comprises a rotatable dove prism or other mechanical device or mirror equivalent. If so, the control means may be arranged to control the rotation of the dove prism about the longitudinal axis of the light beam.

The apparatus may further comprise beam generating means for generating the light beam and beam shaping means for altering the shape of the light beam to generate the image in the light beam. The beam shaping means may comprise a selective light reflecting or transmitting device. This can enable the

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shape of the image to be dynamically controlled. The light reflecting device can comprise a plurality of digitally controllable micromirrors, P-Si with a micro-lens array, D-ILA or any other suitable image delivery system.

5 The present invention also provides a method of projecting an image in a light beam by deflecting the beam using first light deflection means on to second light deflection means, and rotating both light deflection means so as to deflect the beam substantially in any direction, the method comprising the step of rotating the image in the light beam using image rotation means.

10

Preferably, the method further comprises the step of controlling the rate of rotation of the image by the image rotation means. The rate of rotation of the image by the image rotation means may be calculated from the rate of rotation of each of the first and second light deflection means.

15

Preferably, rotation of the image due to the deflection thereof by the first and second light deflection means is compensated by the rotation of the image by the image rotation means. In one preferred embodiment, the image rotation means comprises a rotatable dove prism.

20

A further aspect of the invention provides video image recording apparatus, comprising

- a video image recorder;
- first and second rotatable light deflection means for deflecting light in different directions, the light being deflectable by the first light deflection means on to the second light deflection means; and
- image rotation means for rotating an image in the light;
- wherein the first and second light deflection means can be so moved as to deflect light from substantially any direction through the image rotation means and into the video image recorder.

30

This confers the advantage that the video image recorder can be statically

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mounted but nevertheless used to record a video image emanating from substantially any direction. The recorder is preferably a video camera.

5 In a specific embodiment of the invention, the video camera is a security camera. The invention thus enables the security camera to be securely mounted whilst movement of the image rotation means and the light deflection means enable pictures from substantially any direction to be recorded. The camera itself can for example be mounted inside or behind a wall, and thus made more remote from and more secure from tamper. Using the image
10 rotation means, whether electrical or mechanical, to compensate for rotation of the image due to deflection off the deflection means has the result that an upright image can be recorded whatever its origin relative to the stationary camera.

15 It is further preferred that the recording apparatus includes focusing and zoom control means according to the first and second aspects of the invention, to enable adjustment of focus and zoom according to the distance from the apparatus to the subject being recorded. In conjunction with focus and, or zoom control a distance detector can be provided for dynamic adjustment of
20 these parameters.

The invention is now described in specific embodiments with reference to the accompanying drawings in which:-

25 Fig. 1 shows a schematic view of a beam steering apparatus;

Fig. 2 shows a schematic control system;

30 Fig. 3 shows a schematic diagram of operation of a projection system;

Figs. 4 & 5 show calculation of distortion correction;

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Figs. 6 to 10 show representation of the image processing for calculation of distortion correction

5 Fig. 11 shows the optical path in an embodiment of image projecting apparatus of the invention; and

 Fig. 12 shows a schematic diagram of a further embodiment of projection apparatus of the invention.

10

Particular embodiments employ apparatus having a system of rotatable mirrors. Apparatus for directing a beam of light by rotatable mirrors is known from US 4,663,698 and is illustrated schematically in Figure 1. The apparatus comprises a first mirror 10 on a rotating first support, or "pan", 12 which is
15 mounted to apparatus body 14. The body 14 includes a light source, such as a lamp 16, and focusing arrangement 18. Using a belt drive, the pan 12 is rotatable about pan axis 20 by a motor 22 mounted on the body 14.

A second mirror 24 on a rotating second support, or "tilt", 26 is mounted on the
20 pan 12. Using another belt drive, the tilt 26 is rotatable about tilt axis 28, orthogonal to the pan axis 20, by a motor 30 mounted on the body 14. This arrangement of rotatable mirrors can direct a beam of light in many directions and is used for moving a white or coloured light beam. Beam steering apparatus using a pair of rotatable mirrors is also described in our co-pending
25 International patent application no. WO 99/41544, the contents of which are incorporated herein by reference.

However, a double-mirror system is not the only means by which the image projected may be moved around a projection surface. In certain embodiments,
30 the output of the projector may be steered by the use of optical fibres. Such fibres may be disposed in front of the projector, and flexed in any direction in which the beam is intended to be projected. In embodiments, there is a fibre or

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conduit for each element of the picture; in one embodiment, a fibre for each pixel of the image, and in another, a fibre for each mirror of a digital micromirror type device used in the projector.

- 5 In a particular embodiment, the projector may be mounted on a moving yoke. In this manner, the movement of the beam across a projection surface is simply accomplished by movement of the projector itself. In an embodiment, the projector may be moved throughout any given angle on the yoke, and in this case, the processing of the image may involve inversion of the image, if the
10 projector passes through "top dead centre", that is, through such an angle that the image ceases to be projected the right way up, as seen by a viewer.

To begin with, the system for control of the processing of the image information will be described, followed by description of examples of apparatuses on which
15 the system may be supported.

The control structure includes various features, controlling aspects of the images to be projected such as focus and zoom attributes, distortions, such as keystoneing and similar effects caused by the angles of the projection surface
20 relative to the projector, rotation of the image, fade, and others. Although all of these elements may be satisfactorily controllable via an interface to the chosen projector, that may not always be the case.

Principal User Interface (PUI)

- 25 This is, in an embodiment, made up of a traditional lighting desk, a computer based graphics engine and some form of image processor function (in this case a CPU) to combine the two and drive the head. A number of options exist for the processor, though it is preferred to incorporate as much of the processing functions in existing hardware (i.e. the PC graphics engine platform and the
30 lighting desk).

There are three principle options available for the PUI, and whilst the following

- 20 -

are quite different, they will incorporate all the elements of the control system as depicted in Figure 2.

Option 1: PUI - The Controller

- 5 In this option, the lighting desk is the controller with sole control of all attributes. As well as the primary output channels to control focus, zoom, pan and tilt there are also several dedicated data channels designed to call up pre-defined cues on the graphics engine. All input processing is thus a function of the desk, feedback is a closed loop system within the head.

10

Option 2: Attributes via CPU

- In this version all the attributes are a function of the CPU (the CPU also acting as the PUI) with a separate user interface combining attribute control and graphics editing. The show is programmed using trigger points at cue changes on the timeline that in turn are triggered by the lighting desk via DMX. The lighting operator thus has no direct control through the desk of any attributes other than blind programming the required triggers.

15

Option 3: Custom System

- 20 The final option is a completely standalone system that controls imageering, attributes and feedback with a suitable graphical user interface, also acting as the PUI. This system is programmed and operated independently of any other controllers, although it is possible to accept external triggers if used as part of a timecoded show.

25

Attributes

A description of the principle attributes is detailed below with reference to Figure 3.

30 Image distortion

A principal function of the digital image processing system is to correct for distortions in the projected image where caused by the characteristics of the

- 21 -

projection surface. Projection surfaces, such as stage sets, theatres, stadiums, cinemas, and other audio/visual forums will typically have vastly varying characteristics. In particular, however, similar problems will arise. For example, if an image is projected onto a plane surface, unless the axis of projection is
5 normal to the plane, a "keystone" type effect will be introduced, distorting the image into whichever direction the plane deviates. An example of this is shown in Figure 4.

Taking this example initially, such a simple distortion as keystone may be
10 treated in several ways. It is possible to set up a closed loop feedback using a four axis range finder but such technology may be expensive in a system as described.

It is further possible to perform any correction automatically based on spatial
15 coordinates, as it will invariably need correcting depending on the plane of the projection surface. The matrix for the correction is depicted in Figure 4. From the diagram it can be seen that around the zero reference datum a vertical correction requires adjustment of $-x_3 + x_4$ and $-x_1 + x_2$. Similarly, for a horizontal adjustment the correction needs to be $-y_3 + y_4$ and $-y_1 + y_2$. Using the positional
20 matrix shown, the result is output to the imageering software, which computes the required distortion. In embodiments employing a double-mirror system, a transformation can be applied based on the angle of the pan and tilt axes.

Where $x' y'$ is the corrected value, and $\delta x \delta y \delta z$ are the change in locator from
25 the spatial preset, an example of the function used is shown in Figure 5.

It may also be useful to have a manual override of rotation direction and speed in the PUI to give the flexibility to the designer of rapid image manipulation rather than relying on performing the task as a timed event through the image
30 software. In this respect it may be necessary to develop the positional matrix function and apply scalar multiplication based on the initial spatial coordinates. It may be necessary to add also any revised rotational information from the PUI

- 22 -

to the matrix.

In more complex situations, the distortion will be due to multiple planes on the projection surface. In these cases, the simple matrices used above may be
5 extended to performing a rotation of the image in several regions to produce a compensation for the shape of surface encountered. For example, a corner may be corrected for by splitting the image into three sections, and applying a different distortion correction for each region.

10 Figures 6 to 10 illustrate this embodiment (Figures 6 to 9 employing a double-mirror system). The projector (301) produces a beam in direction (302). 303 and 306 represent the mirrors which reflect the beam. The processing performed is to rotate the image, or parts thereof, about an axis identified (or
15 multiple axes, for more complex corrections). The axes, the portions of the image to be modified and the angle of rotation are related to the orientation of the surface(s) upon which the beam is projected. In reference to the figures, these corrections effectively dictate what "shape" the representative mirrors would have to take in order for the required correction to be obtained. Thus the representations 303 and 306 are rotated about given axes in the software
20 domain, as shown at 304, in figures 7, 8 and 9, in order to produce the correction necessary. Hence, before the image is projected, the image is effectively distorted for correction by the rotations imposed, and upon projection is reflected by the actual mirrors onto the projection surface, producing the required correction on the projection surface.

25

In Figure 10, the various rotations and axes (the single lines) are shown for a variety of distortion corrections required (shown underneath). For example, 901 shows a simple keystone-type correction in the right-hand part of the image. 902 shows a double correction or "fold", as might be employed, for example, for
30 projection of an image onto corner in a stage set. 903 shows the correction for a corner having three faces, as might occur if an image were projected into a vertex between two walls and a floor area.

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It should be noted that the double-mirror system described is not the only system in which the correction described may be employed. For example, the image beam may simply be projected, whilst the projector is moved on a yoke-type system. The movement of the beam would thus still require correction of the projected image for different areas of the projection surface.

In order to speed up the correction process, the topography of, for example, a stage set may be programmed into the apparatus as a 3D model, or may be scanned to produce a mapping. Alternatively, the beam may be projected onto a given surface, and the required adjustments made manually and recorded.

Tilt

The tilt operation is straightforward. Currently there is a 12bit signal available where the control amplifier senses incremental or decremental values for direction. 12bit resolution is thus available for both clockwise (T) and counter-clockwise (T') rotation.

Pan

The pan operation is slightly more complex due to the mechanical pan/tilt summation. Whilst the same is true for resolution and direction sensing to give 12bit resolution for clockwise (P) and counter-clockwise (P') rotation, the tilt head also needs to rotate in the same sense and velocity as the pan head, if the pan is to rotate with no change in tilt position. This can either be a function of the CPU or an error correction level to the feedback circuit of the tilt.

Focus

There are several options available with focus (F). One is to use a simple pre-programmable focus which takes an Nbit data signal to give $N/2$ bit resolution from an arbitrary mid-point. Another option is to use a mechatronic range finding system which uses an optical device to adjust focus, such as that found in a camera. If a mechanism proves to be less than effective when trying to

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focus on a uniformly coloured screen with no identifiable relief, a further option is to use the CPU to calculate focal position based on spatial information already input to the processor, and real time positional information from the PUI. Of course, further methods will be apparent to the skilled reader.

5

Different amounts of focus may be added or removed from an image, in that an image may be blurred to a certain extent, and thus "sharpened" back to the original image if need be. For example, images falling onto a set not normal to the beam will be more in focus in parts than in others. Thus, the electronic
10 focus processing may correct for this. Additionally, other effects may be created, such as depth effects. For example, an image may be projected onto several surfaces on a stage set, and the focus varied for each surface, so as to create the effect of scenery receding into the distance.

15 Zoom

Zoom is typically a straightforward attribute with control from the PUI. In this embodiment, the control signal is again in the form of an Nbit data signal giving $N/2$ bit resolution from an arbitrary mid-point.

20 Rotation

There are two options available for rotation (R) of the image. One is to perform an opto-mechanical transform based on the home position of the head and the default image orientation set in the imaging software. As the pan and tilt rotate the image is contra rotated to keep it in the correct orientation at all times. The
25 second is to use a software algorithm to perform the same task based on default spatial coordinates.

Here, it may also be required to have a manual override of rotation direction and speed in the PUI to give the flexibility to the designer of rapid image
30 manipulation rather than relying on performing the task as a timed event through the image software. Again, in this respect it may therefore be necessary to develop the positional matrix function and apply scalar

- 25 -

multiplication based on the initial spatial coordinates.

Fade

The fade is a fairly straightforward function of the graphics engine. A single 8bit
 5 channel gives smooth fading between full on (0xFF) and complete blackness (0x00). If the projector is run in RGBS or composite video the image software may not be able to cope with a fade to black - the options are then to use a mechanical dimmer which may add complexity or to fade to an external black burst generator.

10

Table of Functions which may be required.

Attribute	Function 1	Function 2	Function 3	Function 4
Pan	Rotate C (P) + 12 bit	Rotate CC (P') - 12 bit		
Tilt	Rotate C (C) + 12 bit	Rotate CC (C') - 12 bit	Pan compensation* +/- 12 bit	
Focus	Increment + 4 bit	Decrement - 4 bit		
Zoom	Increment + 4 bit	Decrement - 4 bit		
Rotation	Increment + 12 bit	Decrement - 12 bit		
Simple Keystone	X_1Y_1 +/- 4 bit	X_2Y_2 +/- 4 bit	X_3Y_3 +/- 4 bit	X_4Y_4 +/- 4 bit
Fade	Full on	Full off		

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	+ 8 bit	0		
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*Note that pan compensation is not strictly a function of tilt, but is highlighted to illustrate the correlation.

- 5 Various other corrections and effects may be introduced by the image processor. For example, images may be handled as texture maps, enabling a projected image to be rendered as if it was falling upon a three-dimensional object, even though the actual screen may be flat. For example, in software a sphere may be selected and a world map rendered onto it, controlling the
- 10 processor from a lighting desk, manipulation of the controls, using a combination of the x,y,z software rotations, the globe may be set in motion at any speed or direction with any desired polar inclination.

- In an image overlay a texture map treatment of images allows one image to be
- 15 overlaid by another by rendering parts of one, more or less transparent, allowing the other to either show through in parts or to the two images to merge. One or more of the overlain images may be a moving image, for instance, a full colour moving image of a flames might be overlain with a static mask representing the bars of a grate, or the area behind an image of a
- 20 building might be filled with changing images of sky, such as storms, clouds, and sunset.

- In another effect, a large image, still or moving, may be held in the processor/framestore and a relatively small area of the image may be
- 25 projected, either in the native format of the projector or through an electronic mask, such as a circle – porthole or rectangle - window, the image may then be panned, zoomed or rotated, as if behind the mask. This technique might be used represent a scene passing a carriage window or suchlike.

- 30 Alternatively, an image, still or moving, may be held in the processor as if it was covering a large area of the set or screen, but only a relatively small part is

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actually projected (using either the native format of the projector or through an electronic mask), such as a circle representing the view through a telescope. In this case, the large stored image is kept stationary and the "mask" (by way of moving the projector beam by mirrors or yoke, or purely in the software domain) is moved over it, revealing only that part of the image on which the 'telescope' is trained.

CPU and Image Handling

10 CPU Function

The CPU acts as the main processor for all the graphics functions, taking in the image and performing the required algorithms to achieve the desired output. The inputs comprise positional information, attribute override and graphics. The output is either graphics only if a remote PUI is used, or all six attributes plus graphics.

Feedback to the CPU is required giving actual status information of all six attributes so that a fast and accurate image:position calculation can be performed. This also has the benefit of accounting for any external errors that may occur.

Whilst such feedback is ideal, it is not strictly a requirement. When a MOVETO command is received, there is a calculable response time dependant on speed and final location of the command, and assuming that the system is satisfactorily damped, the control function for such a move (based on criteria such as inertia and input slope) can be applied to any image as a transformation speed. This applies to any image where the MOVETO command is a point to point command, i.e. move from $x_1y_1z_1$ to $x_2y_2z_2$. It would not be applicable to the duration of a continuous rotate, only the start and stop instruction.

CPU Speed

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The CPU is capable of calculating the new positions of multiple attributes concurrently, or at least very fast, as well as performing processor intensive functions such as image rotation (should a software option be taken). An indication of the speed required could be gleaned from looking at the speed of the triggers. Assuming that the attribute commands come from the lighting desk which is outputting DMX512, and that no attributes are set to "auto", the worst case would be as follows.

Video Imaging

There are two ways of calling up from the image bank. The first is to have a library of images or video clips accessible from the lighting desk. Each of the 0xFF bits of a channel could relate to 0xFF memory locations in the CPU which in turn contain an image such as a gobo or a video clip. The programmer would then call up said location as part of a cue.

The alternative is to use a channel or two as cue triggers; the images and clips are assembled as a show in themselves with each change of image given a marker on the timeline. Such markers would be activated on the change of state of the DMX channel, e.g. a change from 0xAA to 0xAB moves the image software to the next trigger mark.

Examples of the apparatus which may be used to employ the above image processing will now be described.

With reference to Figure 11, the optical path of an embodiment of an image projecting apparatus, here employing a double-mirror system, is shown generally as 100. The apparatus comprises a beam source 102 for generating a beam of light. As shown in Figure 11, the beam source 102 comprises a lamp 104 and an ellipsoidal (or other concave-shaped) reflector 106, the lamp 104 being situated at the focus of the reflector 106 to provide a broad, parallel beam of light. Instead of being a parallel beam, the beam may be converging or diverging, the apparatus including, if desired, suitable means for focusing the

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beam.

The light beam generated by the beam source 102 is incident upon an image generating engine 108, which alters the shape of the light beam to generate an image in the light beam. The engine 108 may take any suitable form; examples
5 include a digitally controllable light reflecting device. Such a digitally controllable device is available from Texas Instruments, Inc., and typically comprise a plurality of digitally controllable micromirrors which are selectively moveable to either deflect light away from the optical path, in which case a dark
10 region will appear in the resultant projected image, or towards the optical path. Red, green and blue scales in the image can be obtained by the modulating the device at high speed, and moving a colour wheel in the light path. Typically, the micromirror device is operated at three times the normal speed and the resultant red, green and blue images are integrated by the human eye into a
15 colour image.

The image output from the engine 108 is incident upon a dove prism 110. The prism 110, having a different refractive index to air, refracts the light beam as shown in Figure 11, with the result that the image in the light beam is laterally
20 inverted. The principle of the dove prism is well known and will not be discussed further.

The image output from the dove prism 110 is focused by objective lens 112 onto beam steering apparatus 114. In the embodiment shown in Figure 11, the
25 beam steering apparatus comprises a pan 116 including a first planar reflector 118, such as a mirror, the pan 116 being rotatable about pan axis 120.

A tilt 122 is mounted on the pan 116 and includes a second planar reflector 124, such as a mirror, and is rotatable about a tilt axis 126 substantially
30 orthogonal to the pan axis 120 so that the mirrors can direct light in substantially any direction for projection through an aperture in the tilt 122. The planar reflectors, or parts thereof, may comprise a plurality of mirrors at different

- 30 -

angles to each other, forming a mosaic of mirrors. At least part of one or both mirrors may comprise a diffuser. As an alternative to planar reflectors, the pan 116 and tilt 122 may include any suitable means for deflecting the light beam, such as lenses, prisms, interferometric mirrors or fibre optics.

5

In addition to, or alternative to, the objective lens 112, one or more beam focusing means, such as lenses, may be arranged at any suitable point within or external of the beam steering apparatus 114.

10 As discussed above, if the image projected from the beam steering apparatus 112 is swept about, for example, a vertical axis, the image will rotate about the longitudinal axis of the light beam due to the deflections of the image within the beam steering apparatus. In order to compensate for this rotation of the image, the dove prism 110 is rotated about axis 128 co-axial with the longitudinal axis
15 of the light beam incident thereon. This rotation of the dove prism 110 has the result of rotating the image output from the dove prism 110. By co-ordinating the rate of rotation with the rates of rotation of the pan 116 and tilt 122, the rotation of the image by the dove prism 110 can compensate for the rotation of the image due to the deflections thereof within the beam steering apparatus
20 114.

The dove prism 110 may be rotated by any suitable means under the control of suitable control circuitry. The control circuitry is arranged to calculate the required rate of rotation of the dove prism 110 from the rates of rotation of the
25 pan 116 and tilt 122. In addition to compensating for rotation of the image due to deflections thereof in the beam steering apparatus 114, rotation of the dove prism 110 may be separately controlled to produce a desired rotation of the projected image. Feedback from the beam steering apparatus 114 via a processor (not shown) to the image engine additionally provides correction in
30 the image engine for keystone-type distortion introduced by the beam steering apparatus' projection of the image onto a lane which is not normal to the axis of projection. Feedback as to the distance to a viewing surface is used to adjust

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the focus by objective lens 112.

Referring to figure 12, a projection system 200 comprises a twin axis, double mirror, orbital head with universal mounting 201, focus and zoom mechanics
5 incorporated within the head assembly (not shown), means for positional feedback to/from the orbital head, via DMX through link 202, to direct the head position and to feedback the position of the head, output and input via DMX through link 203 to/from a computer controller 205 having a Windows operating system embedded in a proprietary video-graphics software platform, and a
10 controller 205. The apparatus may be resident on a high specification, rack-mounting, PC with high capacity hard disks, and a S-VGA VGA, XGA, S-XGA, UXGA or higher resolution video graphics cards. A laptop computer-based lighting controller, or lighting desk, is also suitable with resident cueing index providing access to images resident in the PC. Other configurations of the
15 apparatus, comprising alternative digital processing, storage and information transfer will be apparent to those skilled in the art.

The double mirror head is shown coupled to the output of a video projector 206.

The head incorporates focusing and zoom lenses, under control of motors
20 whose operation is in turn controlled via inputs from the master controller. Motors to control the positions of the mirrors are likewise under control by the master controller and feed back is in place as to the position of the mirrors in the head from the head to the master controller.

25 Image processing means 207 has an input 208 for image data from the graphics store 210 and an output 209 for sending processed data to the projector 206. A separate input via DMX through link 203 receives instructions from the controller as to the processing to be carried out on the image data from the graphics store. The controller has an output 204 to a monitor 212 to
30 enable the operator to see the effects being projected or to be projected in future. The controller has an input 202 from the head and an output to both the head and to the image processing means via link 203 and a separate RS232

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link 211 with the graphics store 210.

In use, image data is provided to the image processing means from the graphics store in the PC. The controller directs a signal to motors of the head to effect an orientation of the mirrors of the head so as to deflect the beam from the projector in a chosen direction. Data as to the orientation of the mirrors is provided to the controller as a feed back to confirm their positions. The controller directs a processing signal to the image processing means, which processes the image data so as to introduce a correction for the expected rotation and other distortion effects that will be the result of passing through the double mirror head. The controller also directs a signal to the motors of the head that control focusing and zoom lenses on the head to ensure the projected image is at a desired focus and a desired zoom. The image is projected with desired orientation, focus, zoom and appearance. It is also possible for the controller to send instructions to the head and the image processor at the same time, in which case feedback from the head can be omitted.

Management of the images is carried out in a system using the following elements:-

A library: This holds the images on a remote PC, one per head. There may be a very large number of these images. A way of searching for images using keywords via an external controller, one per system, can be incorporated.

An editor: This enables the user to open up any image and edit it accordingly. For example, it allows the user to add and edit text to library images.

A timeline: This provides a schematic representation of the sequences and acts as the backdrop upon which to hang the images, this element being the main point of interaction between user and apparatus.

A preview screen: In conjunction with the timeline, this provides a way

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of visualising the show. This preview screen can play through the sequence, applying the transformations in the sequence defined in the timeline.

5 Pre-programmed transforms: The majority of transformations are accessible from the user interface, any transformation which is envisaged as being often used is easily found and incorporated.

User-definable transforms: For users to create and incorporate their own transforms into the software and to have these accessible easily.

10 Control of the image via software is achieved, so that orientation, keystone/perspective correction, rotation, direction, speed and other manipulations are all be available via the graphics package resident in the rack-mounted PCs.

15 The head is controlled by 16-bit DMX 512 to 12-bit resolution driven by a hybrid stepper motor and driver. Smooth travel, accuracy and repeatability preferably take priority over high speeds. A feedback interface optionally allows the image orientation to be synchronised to the position of the head.

20 Programmable focus may be carried out by mechanics resident in the head assembly, and controlled by DMX. Integrated control is carried out from a laptop installed with proprietary lighting control surface. Another control method is to use a known desk, such as the Flying Pig Systems Wholehog (registered trademark) desk. Use of such a lighting control desk can also provide access
25 to an image library, for selection and cueing of images and application of video effects.

 Though the embodiments above have been described in relation to single projectors, the invention is not restricted as such. In a particular embodiment of
30 the invention, a plurality of image beams are created (for example, by a plurality of projectors). The beams may originate from different points in a projection system, in order to create certain lighting effects. With the ability presently

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described system to process the whole image to correct many types of distortion, projectors may be placed in largely different positions whilst their images may still be registered on the same area by correcting the relative distortion. In this situation, for example, an area of screen or set behind an
5 obstacle may be covered, in whole or in part, by one or more projector beams having an advantageous angle.

Further, if there is an obstacle before the set/screen it may be, for example, mapped in memory, identified by video camera image, or simply outlined by
10 hand on a graphics tablet or similar, and that area of the beam falling on the obstacle may be modified by wholly suppressing the scenic image or replacing it with a different image. If the obstacle and or the projector beam is moving, then the information from the video camera trained on the scene, may be processed, and the beam/image of a given projector modified, in real-time, by
15 the processor/image store.

Further variations and modifications will be apparent to one of skill in the art without departing from the spirit of the invention. In particular, various aspects of the invention described may be combined for various corrections or effects,
20 and to create combinations of effects.

CLAIMS

1. Lighting apparatus for creating lighting effects in a set, comprising a digital image projector adapted to receive digital image information and to project an image beam; a beam director serving to direct the image beam in a plurality of directions over the set; and an image processor serving to process the digital image information in accordance with the direction of the beam.
2. Lighting apparatus according to Claim 1, wherein image processor serves to correct for image distortions arising from incidence of the image beam upon surfaces in the set which are not orthogonal to the beam.
3. Lighting apparatus according to Claim 1, wherein the beam director comprises a beam deflector and the image processor corrects for image distortion introduced by the deflector.
4. Lighting apparatus according to any of Claims 1 to 3, wherein the processor corrects for rotation of the image.
5. Lighting apparatus according to any of Claims 1 to 3, wherein the processor corrects for inversion of the image.
6. Lighting apparatus according to any of the above claims, wherein the processor corrects for distortion caused by variation in focus.
7. Lighting apparatus according to any of the above claims, wherein the processor corrects for distortion caused by variation in zoom.
8. Lighting apparatus according to any of the above claims, wherein the digital image processing corresponds to rotation of at least part of the image through a rotation angle about at least one axis of rotation.

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9. Lighting apparatus according to Claim 8, wherein the axis of rotation and the rotation angle are determined from the instantaneous orientation relative to the beam of that surface of the set upon which the beam is incident.
10. Lighting apparatus according to Claim 9, further comprising a data store for storing a model of the set, said instantaneous orientation being determined through reference to said model.
11. Lighting apparatus according to any Claim 9 or Claim 10, further comprising scanning means for mapping surfaces of the set to derive said model.
12. Lighting apparatus according to any of Claims 8 to 10, further comprising a user interface for deriving said model.
13. Lighting apparatus according to Claim 9, further comprising measuring means for measuring said instantaneous orientation.
14. Lighting apparatus according to any one of the proceeding claims wherein the image processor is adapted to process differentially respective image regions.
15. Lighting apparatus according to Claim 14, wherein said image regions correspond respectively with multiple surfaces of the set upon which the beam is simultaneously incident.
16. Lighting apparatus according to any of the above claims, wherein the beam director comprises first and second moveable reflectors, the light beam being deflectable by the first reflector on to the second reflector so as to deflect the beam in said plurality of directions.

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17. Lighting apparatus according to any of the above claims, wherein the digital image information represents moving images and the digital image processor operates in real time.
18. A method of creating lighting effects in a set, comprising the steps of directing an image beam from a digital image projector adapted to receive digital image information in a plurality of directions over the set; and processing the digital image information in accordance with the direction of the beam.
19. A method according to Claim 18, wherein the image processing serves to correct for image distortions arising from incidence of the image beam upon surfaces in the set which are not orthogonal to the beam.
20. A method according to Claim 18 or Claim 19, wherein the image processing corrects for distortion caused by variation in focus.
21. A method according to any one of Claims 18 to 20, wherein the image processing corrects for distortion caused by variation in zoom.
22. A method according to any one of Claims 18 to 21, wherein the digital image processing corresponds to rotation of at least part of the image through a rotation angle about at least one axis of rotation.
23. A method according to any one of Claims 18 to 22, wherein the axis of rotation and the rotation angle are determined from the instantaneous orientation relative to the beam of that surface of the set upon which the beam is incident.
24. A method according to any one of Claims 18 to 23, wherein said instantaneous orientation is determined through reference to a digital model of the set.

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25. A method according to any one of Claims 18 to 24, wherein the image processing serves to process differentially respective image regions.
26. A method according to Claim 25, wherein said image regions correspond respectively with multiple surfaces of the set upon which the beam is simultaneously incident.
27. A method according to any one of Claims 18 to 26, wherein the digital image information represents moving images and the digital image processing operates in real time.
28. Lighting apparatus for creating lighting effects in a set, comprising digital image projection means for receiving digital image information and projecting multiple image beams; means for deriving the relative orientation of the set and the image beams; and image processing means for processing the digital image information in accordance with the derived orientation.
29. Lighting apparatus according to Claim 28, wherein the image processing means serves to correct for image distortions arising from incidence of the image beam upon surfaces in the set which are not orthogonal to the beam.
30. Lighting apparatus according to Claim 28 or Claim 29, further means for directing in a plurality of directions the beam of each image projection means.
31. Lighting apparatus according to any of Claims 28 to 30, wherein the respective image processing means are physically spaced to a substantial extent.
32. Lighting apparatus according to any of Claims 28 to 31, wherein the

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image beams fall on substantially the same point on the set.

33. Lighting apparatus according to any of Claims 28 to 32, wherein the image processing means is adapted to process the image information differentially for projection of respective image beams.

34. A method of creating lighting effects in a set, comprising the steps of projecting multiple image beams from respective digital image projection means adapted to receive digital image information; deriving a relative orientation between each image projection means and a set; and using the orientation in processing the digital image information.

35. A method according to Claim 34, wherein the step of processing serves to correct for image distortions arising from incidence of the image beam upon surfaces in the set which are not orthogonal to the beam.

36. A method according to Claim 34 or Claim 35, further comprising projecting a plurality of image beams from different points.

37. A method according to Claim 36, wherein the image beams fall on substantially the same point on the set.

38. A method according to Claim 36 or Claim 37, further comprising processing the image information differentially for projection of respective image beams.

39. Lighting apparatus for use with a video projector and an image source, comprising:-

a deflector to deflect a light beam from the video projector in a plurality of directions;

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image processing means to process image information, comprising an input to receive raw image information from the image source, a processor to process the raw image information into processed image information, and an output to output processed image information to the video projector; and

a controller that controls operation of the processor of the image processing means according to the status of the deflector.

40. Lighting apparatus according to Claim 39 wherein the image processing means comprises a first memory to store the raw image information and a second memory to store the processed image information.

41. Lighting apparatus according to Claim 39 or 40 wherein the deflector rotates an image in the light beam and the controller directs the processor to process the raw image information so as to provide a correction therefor in the processed image information.

42. Lighting apparatus according to Claim 39 or 40 wherein the deflector introduces a keystone effect into an image in the light beam and the controller directs the processor to process the raw image information so as to provide a correction therefor in the processed image information.

43. Lighting apparatus according to any of Claims 39 to 42 wherein the deflector both rotates an image in and introduces a keystone effect into an image in the light beam and the controller directs the processor to process the raw image information so as to provide corrections therefor in the processed image information.

44. Lighting apparatus according to any of Claims 39 to 43 wherein the apparatus further comprises focusing means and the controller directs the status of the focusing means according to the status of the deflector.

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45. Lighting apparatus according to any of Claims 39 to 43 wherein the apparatus further comprises focusing means and the controller directs the status of the focusing means according to the distance along the beam from the apparatus to a viewing surface.

46. Lighting apparatus according to Claim 45, further comprising a distance detector for determining the distance along the beam from the apparatus to a viewing surface.

47. Lighting apparatus according to any of Claims 39 to 46, wherein the apparatus further comprises zoom control means and the controller directs the status of the zoom control means according to the status of the deflector.

48. Lighting apparatus according to any of Claims 39 to 46 wherein the apparatus further comprises zoom control means and the controller directs the status of the zoom control means according to the distance along the beam from the apparatus to a viewing surface.

49. Lighting apparatus according to Claim 47 or 48, further comprising a distance detector for determining the distance along the beam from the apparatus to a viewing surface.

50. Lighting apparatus according to any of Claims 39 to 43, wherein the controller comprises an output to provide focusing information to a projector according to the status of the deflector and/or according to the distance along the beam from the apparatus to a viewing surface.

51. Lighting apparatus according to any of Claims 39 to 43, wherein the controller further comprises an output to provide zoom information to a projector according to the status of the deflector and/or according to the distance along the beam from the apparatus to a viewing surface.

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52. Lighting apparatus according to any of Claims 39 to 51 wherein the deflector comprises first and second moveable reflectors, the light beam being deflectable by the first reflector on to the second reflector so as to deflect the beam in said plurality of directions.

53. Lighting apparatus according to any of Claims 39 to 52, further comprising coupling means for securely coupling the lighting apparatus to the video projector in such a position that the light beam output from the projector passes through the deflector of the lighting apparatus and so that the output of the image processing means of the lighting apparatus can be coupled to an input on the projector that receives image information of an image to be projected.

54. A light projection system comprising a video projector and an image source connected to lighting apparatus according to any of Claims 39 to 52.

55. Lighting apparatus, comprising:-

a deflector to defect a light beam in a plurality of directions;

beam correction means to impart rotation of an image in the beam;

focusing means; and

a controller that directs the degree of rotation imparted by the beam correction means according to the status of the deflector and directs the status of the focusing means according to the status of the deflector.

56. Lighting apparatus according to Claim 55 wherein the beam correction means comprises a moveable dove prism.

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57. Lighting apparatus according to Claim 55 or 56, further comprising image processing means to process image information, said image processing means comprising an input to receive raw image information, a processor to process the raw image information into processed image information, and an output to output processed image information, wherein the deflector introduces a keystone effect into the image and the controller directs the image processing means to process the raw image information so as to provide a correction for that keystone effect in the processed image information.

58. Lighting apparatus according to any of Claims 55 to 57 wherein the apparatus further comprises zoom control means and the controller directs the status of the zoom control means according to the status of the deflector, or the controller comprises an output for outputting zoom control information to a projector according to the status of the deflector.

59. Video projection apparatus, comprising:-

image processing means to process image information and comprising an input to receive raw image information, a processor to process the raw image information into processed image information, and an output to output processed image information;

a beam generator to generate a light beam from the processed image information;

focusing means to focus the light beam;

a deflector to deflect the light beam in a plurality of directions; and

a controller that controls operation of the processor of the image processing means and operation of the focusing means according to the

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status of the deflector.

60. Video projection apparatus according to Claim 59 wherein the image processing means comprises a first memory to store the raw image information and a second memory to store the processed image information.

61. Video projection apparatus according to Claim 59 or 60 wherein the deflector rotates an image in the light beam and the controller directs the processor to process the raw image information so as to provide a correction therefor in the processed image information.

62. Video projection apparatus according to Claim 59 or 60 wherein the deflector deflects the light beam onto a surface so as to introduce a keystone effect into the image as viewed and the controller directs the processor to process the raw image information so as to provide a correction therefor in the processed image information.

63. Video projection apparatus according to any of Claims 59 to 62 wherein the deflector both rotates the image and introduces a keystone effect into the image and the controller directs the processor to process the raw image information so as to provide corrections therefor in the processed image information.

64. Video projection apparatus according to any of Claims 59 to 63 wherein the controller directs the status of the focusing means according to the status of the deflector and a predetermined distance to a viewing surface.

65. Video projection apparatus according to any of Claims 59 to 63 wherein the controller directs the status of the focusing means according to the distance along the beam from the apparatus to a viewing surface.

66. Video projection apparatus according to Claim 65, further comprising a

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distance detector for determining the distance along the beam from the apparatus to a viewing surface.

67. Video projection apparatus according to any of Claims 59 to 66, wherein the apparatus further comprises zoom control means and the controller directs the status of the zoom control means according to the status of the deflector.

68. Video projection apparatus according to any of Claims 59 to 66 wherein the apparatus further comprises zoom control means and the controller directs the status of the zoom control means according to the distance along the beam from the apparatus to a viewing surface.

69. Video projection apparatus according to Claim 67 or 68, further comprising a distance detector for determining the distance along the beam from the apparatus to a viewing surface.

70. Light projection apparatus, comprising:-

a beam generator to generate a light beam

a beam correction means to impart rotation of an image in the beam;

focusing and/or zoom means;

a deflector to deflect the light beam in a plurality of directions; and

a controller that controls (1) the focusing and/or zoom means, and (2) the rotation imparted by the beam correction means according to the status of the deflector.

71. Lighting projection apparatus according to Claim 70 wherein the beam correction means comprises a moveable dove prism.

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72. Lighting projection apparatus according to Claim 70 or 71, further comprising image processing means to process image information, said image processing means comprising an input to receive raw image information, a processor to process the raw image information into processed image information, and an output to output processed image information, wherein the deflector introduces a keystone effect into the image and the controller directs the image processing means to process the raw image information so as to provide a correction for that keystone effect in the processed image information.

73. A method of projecting an image in a light beam, comprising:-

generating the light beam;

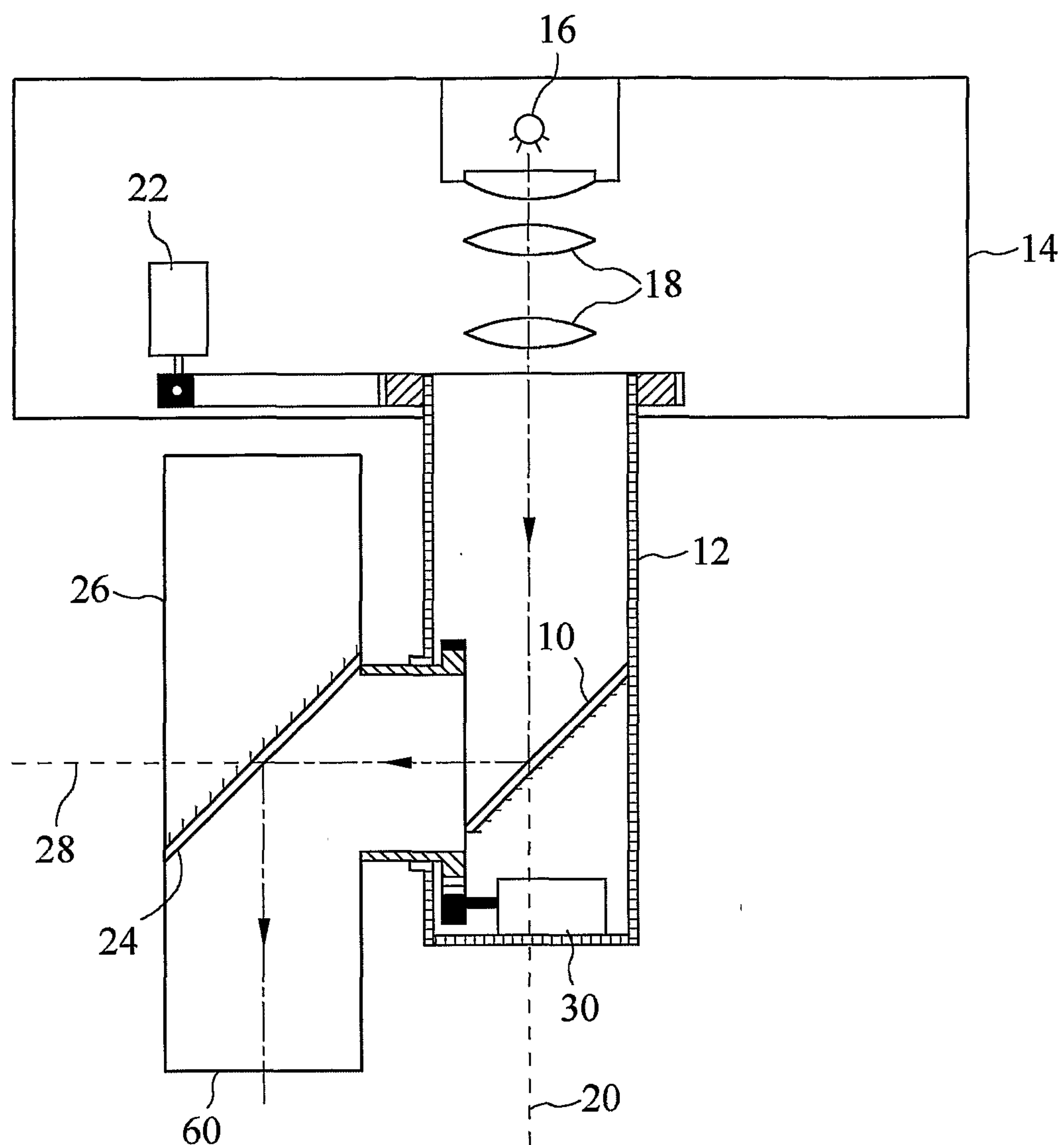
deflecting the light beam by a deflector, the deflector being moveable so as to deflect the beam in a plurality of directions, an effect of deflecting the beam being to rotate the image; and

prior to deflecting the beam, imparting a correcting rotation of the beam to correct for the rotation caused by deflecting the beam,

wherein an effect of deflecting the beam is to change the distance from the deflector to a surface on which the image is viewed, and the method comprises (1) adjusting the focus of the beam according to the change in distance, and/or (2) adjusting the zoom of the beam according to the change in distance.

74. A method according to any of Claim 73, wherein an effect of deflecting the beam is to introduce a keystone effect into the image when viewed, wherein the method comprises, prior to deflecting the beam, introducing a correction to the keystone imparted by the deflecting of the beam.

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*Fig. 1*

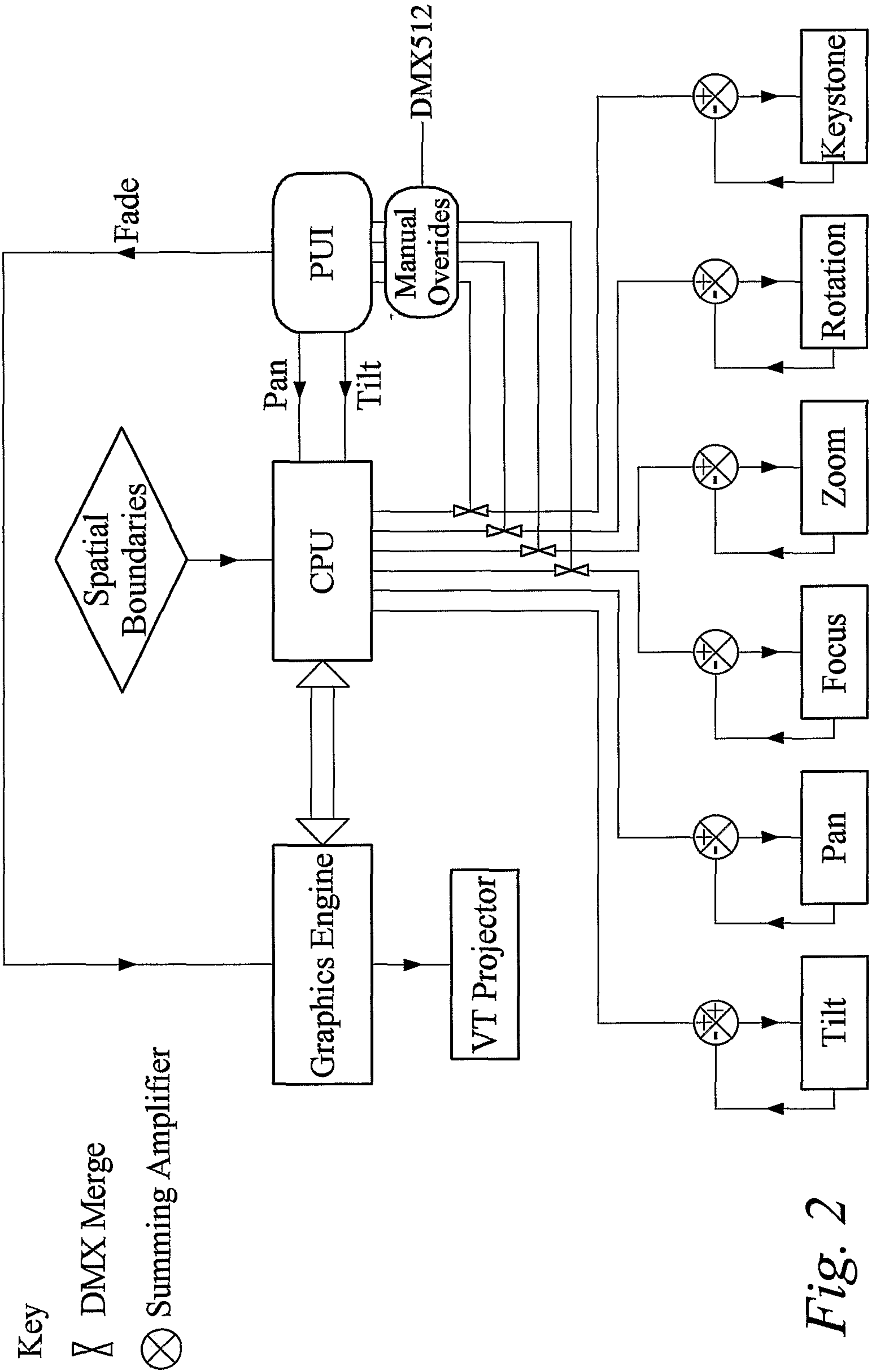
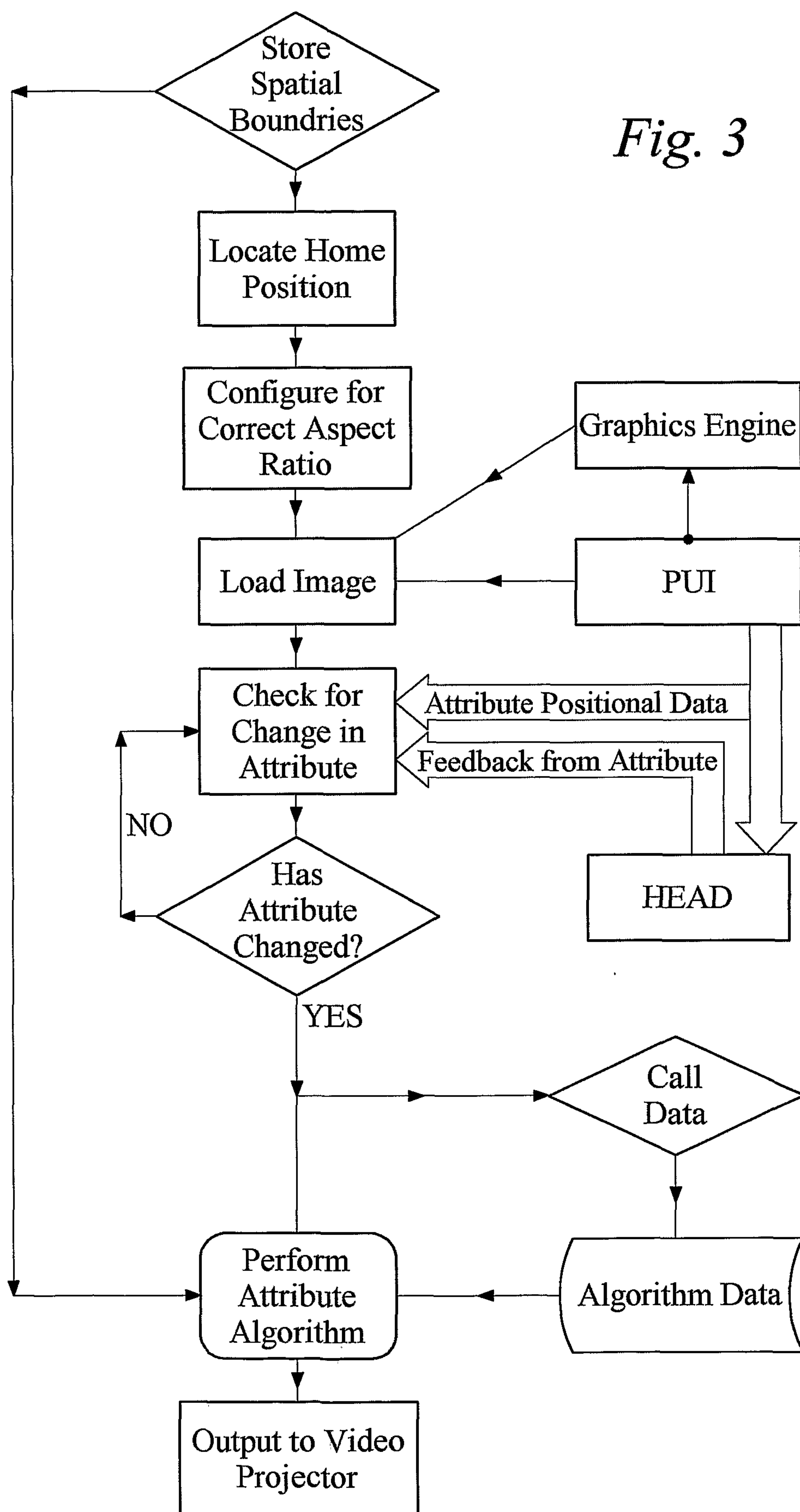
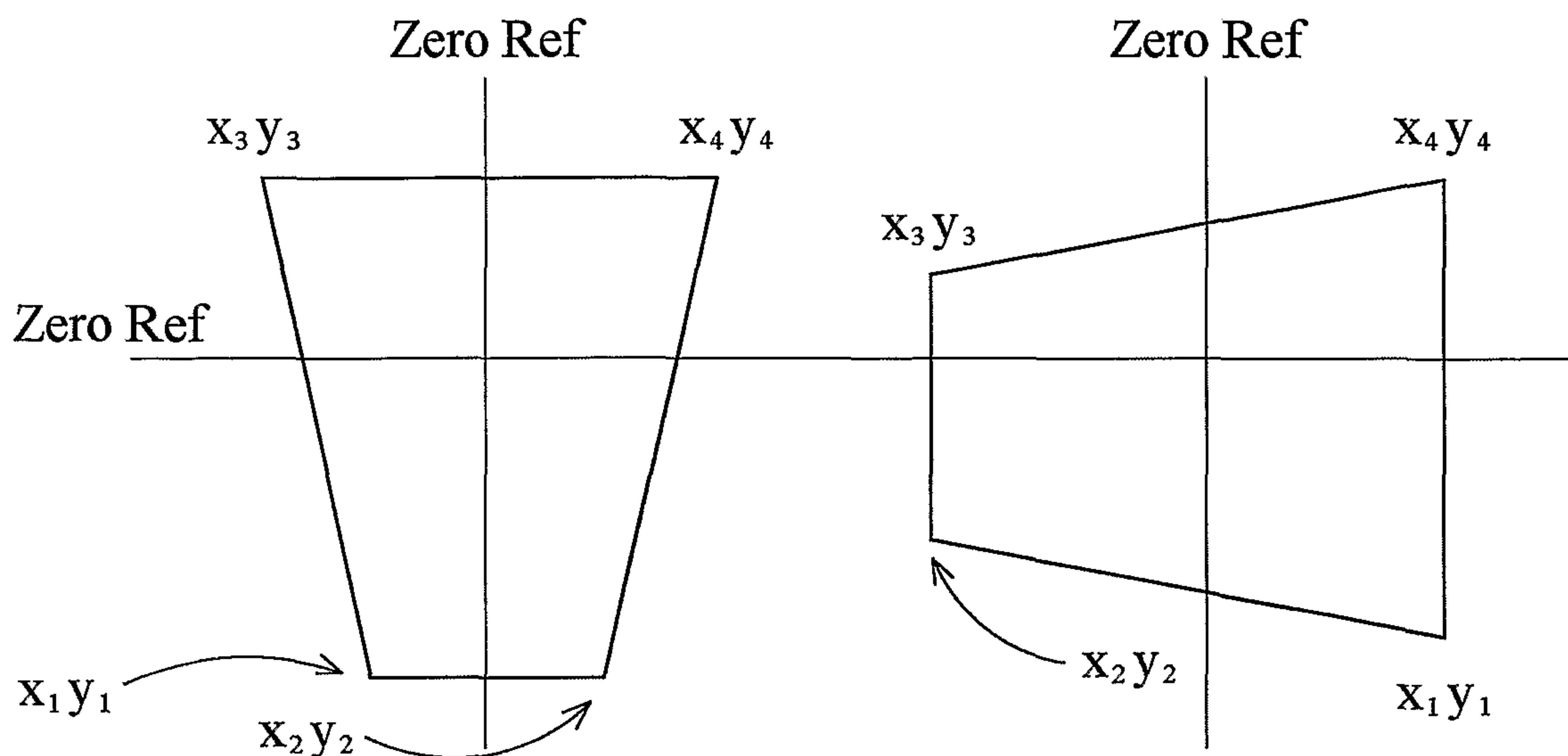


Fig. 2

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Fig. 3

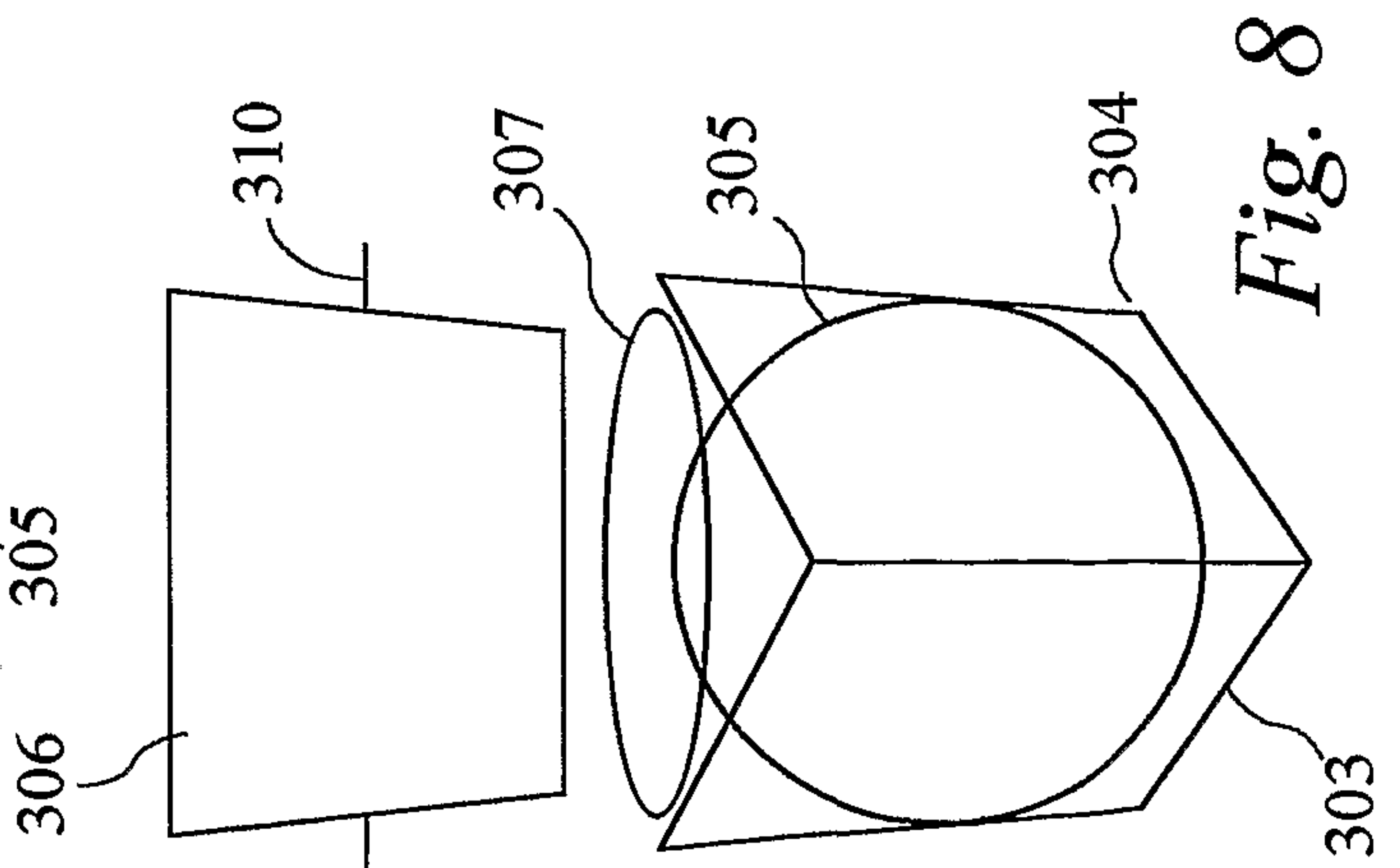
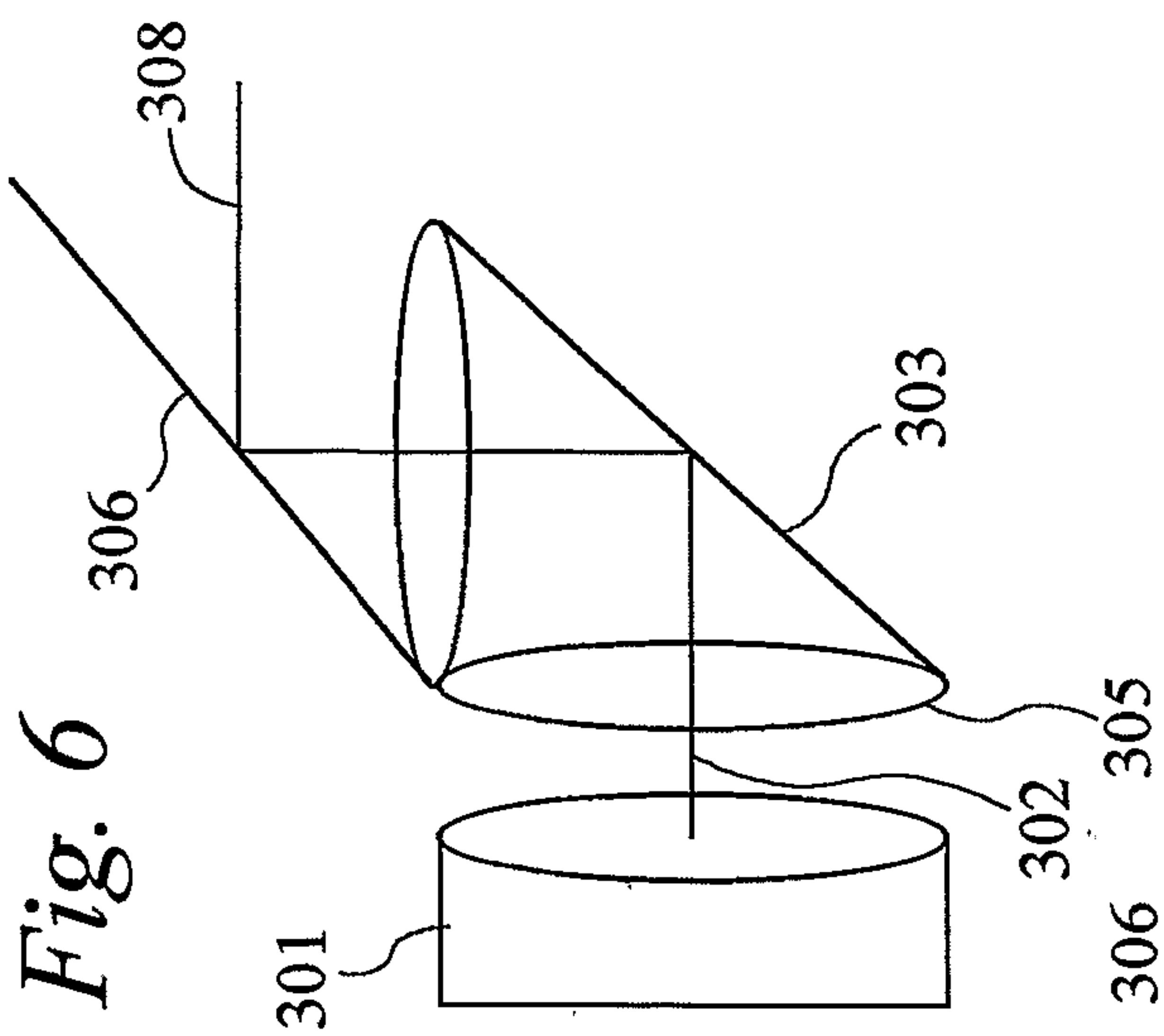
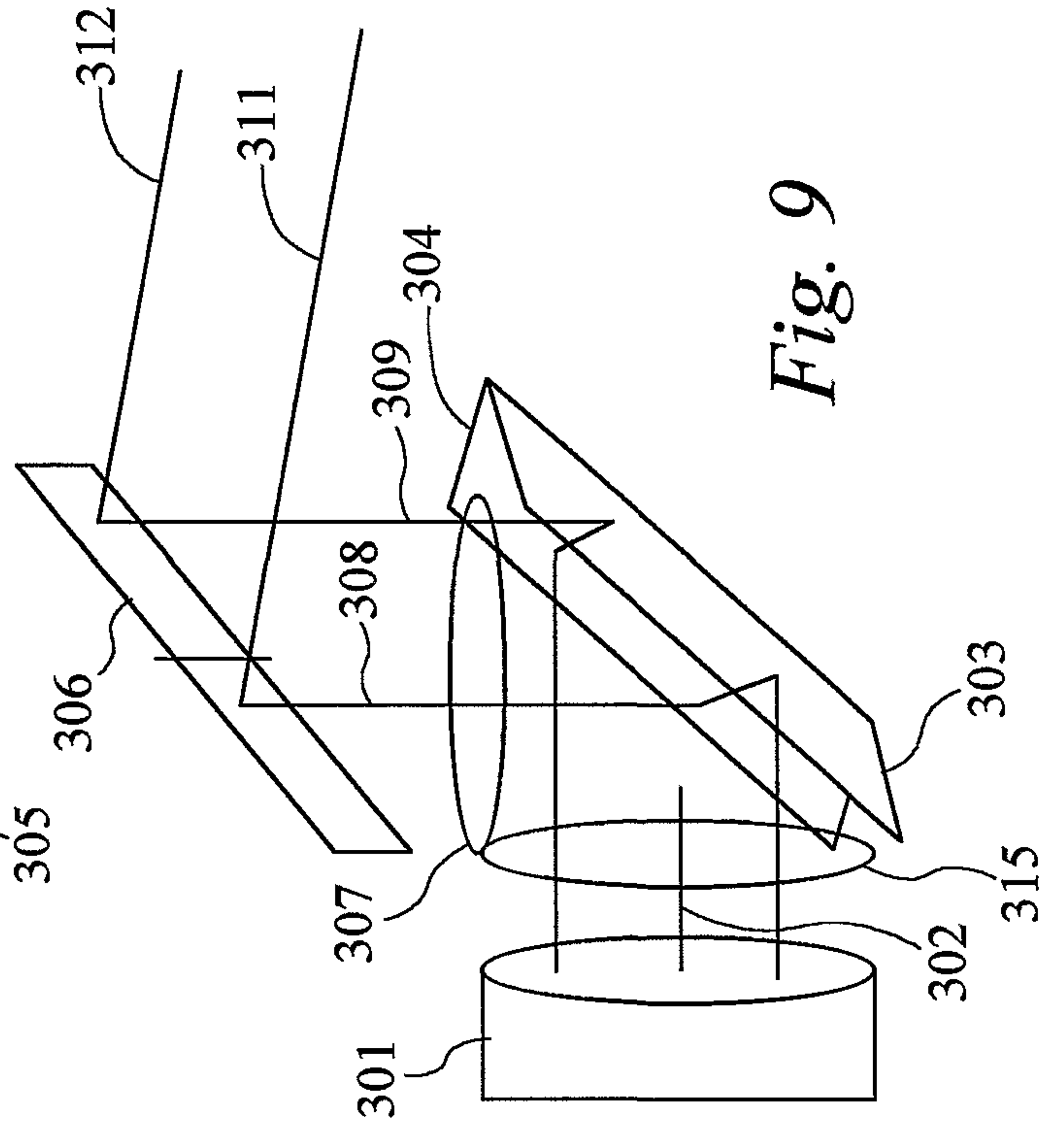
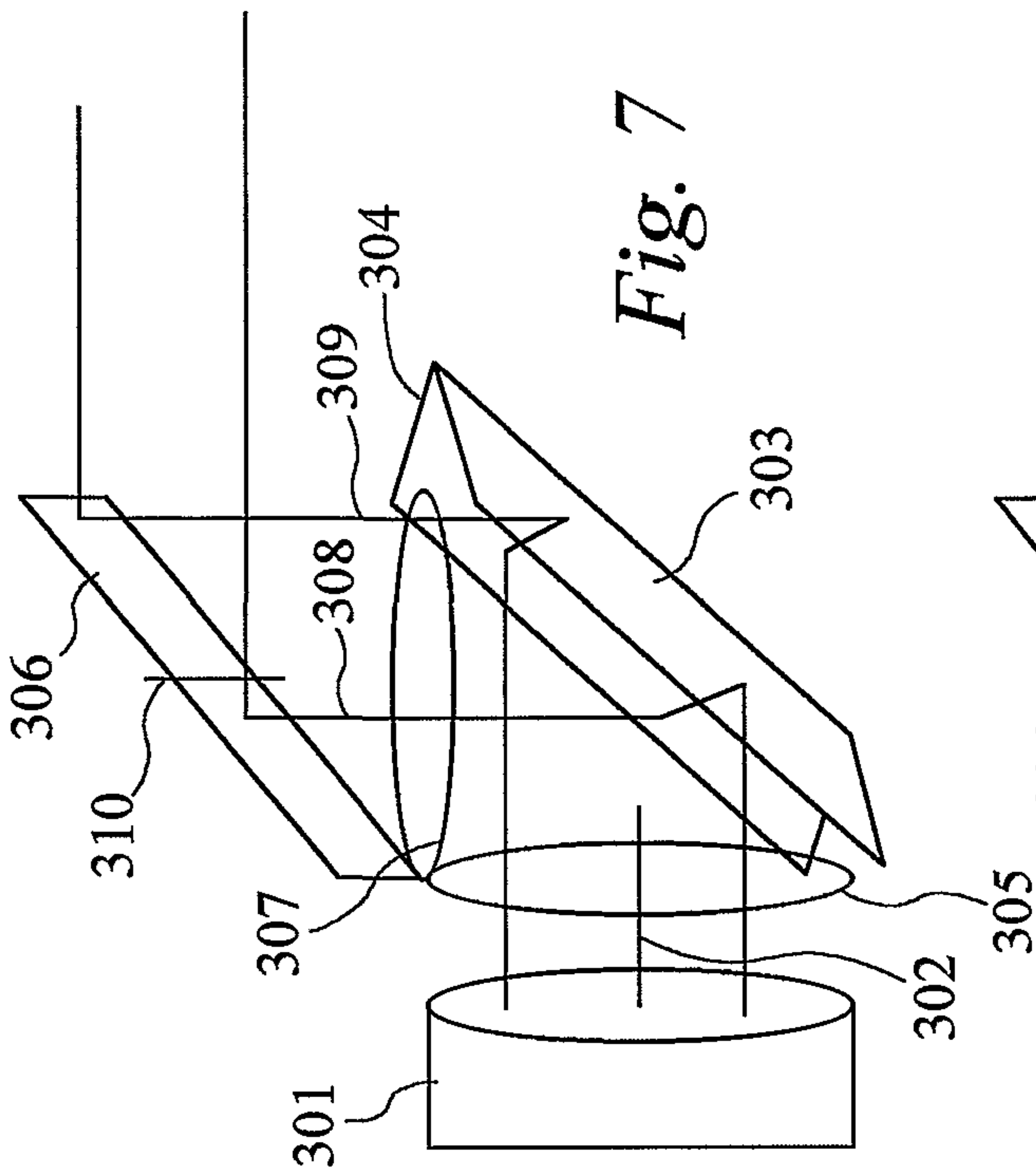
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*Fig. 4*

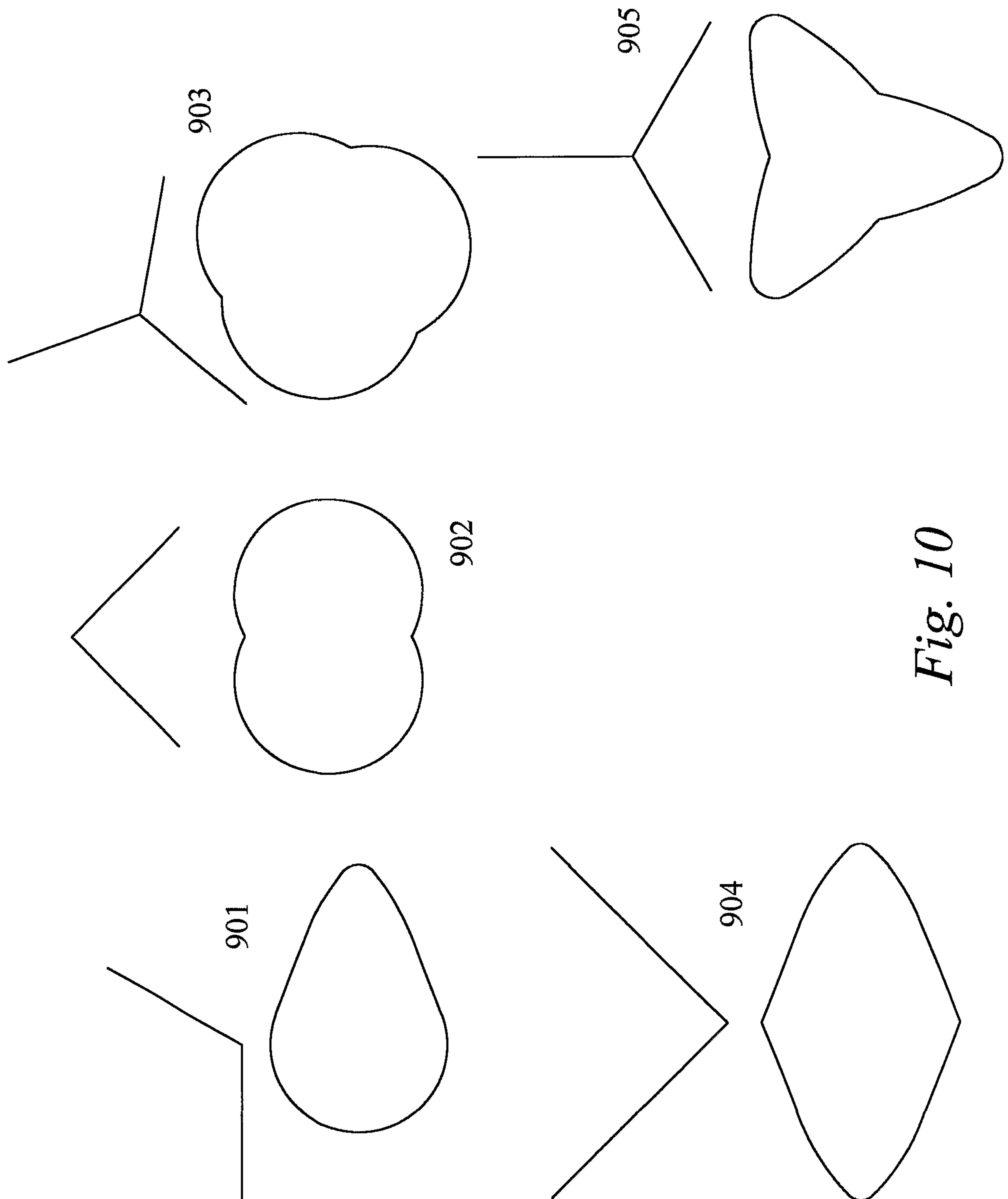
$$\begin{vmatrix} x_1y_1 & x_2y_2 \\ x_3y_3 & x_4y_4 \end{vmatrix} \cdot f\{\delta x \delta y \delta z\} = \begin{vmatrix} x'_3y'_3 & x'_4y'_4 \\ x'_1y'_1 & x'_2y'_2 \end{vmatrix}$$

Fig. 5

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*Fig. 10*

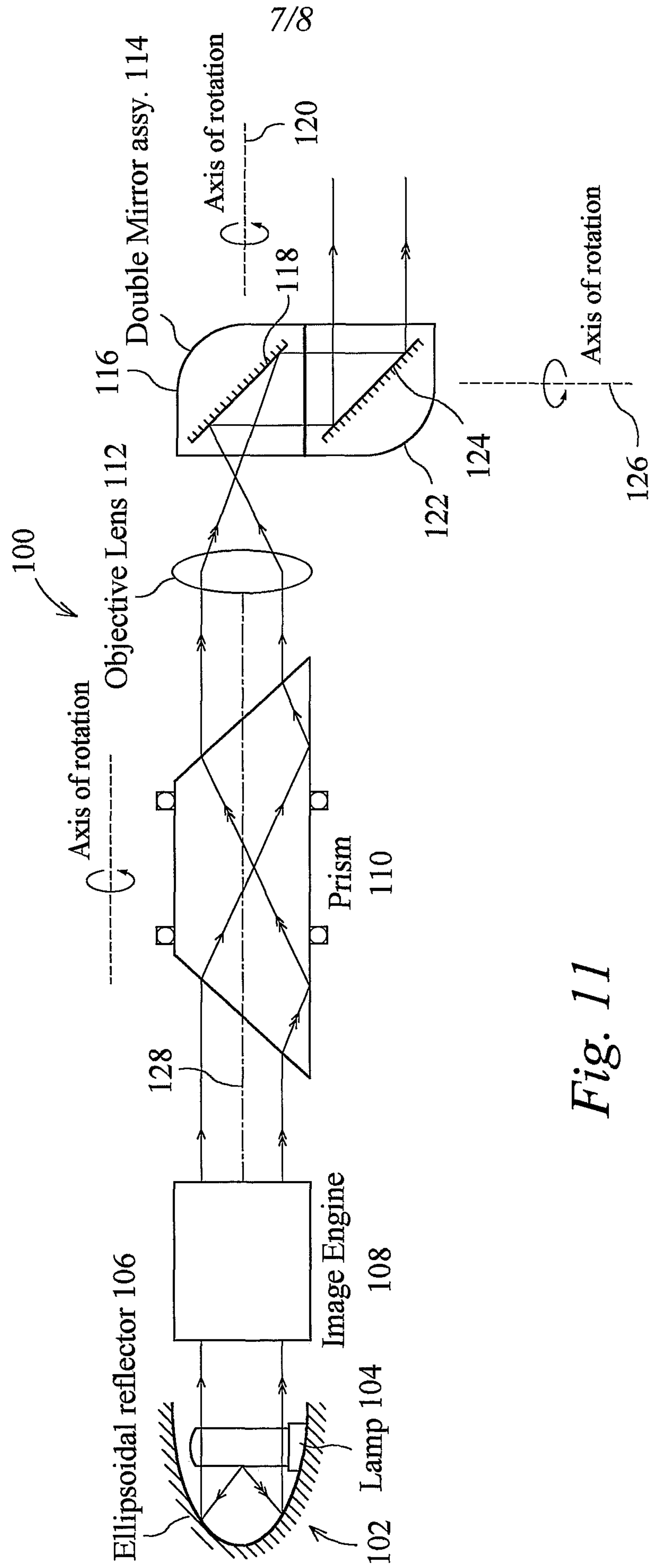
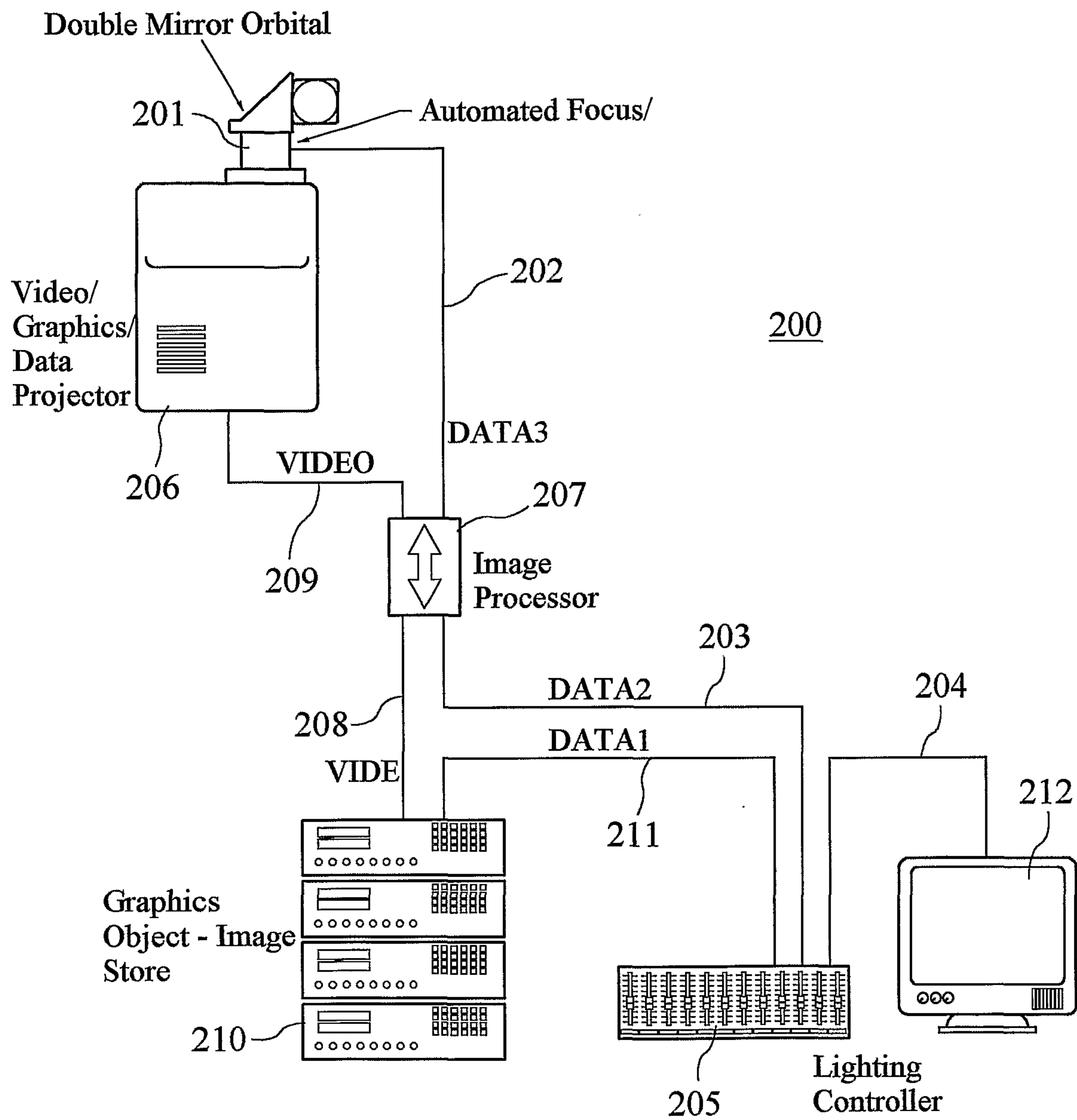


Fig. 11

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*Fig. 12*

