An LCD video projection system (100) uses both polarizations present in the illumination to achieve improved brightness and efficiency. The system divides an unpolarized light beam (23) into two orthogonally polarized beams (24, 27). Both beams propagate along symmetric optical paths and are modulated by the same modulator (10) which may be a liquid crystal modulator. The modulator (10) serves to modulate the cross section of each beam with polarization variations corresponding to an array of pixels (13) which form a video image. The two beams are then analyzed and recombined to form a single unpolarized beam of light (26, 28) whose cross section is intensity modulated with the pixels of said video image. This beam of light may then be projected onto a screen (60) to display the video image.
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POLARIZATION-INDEPENDENT DISPLAY SYSTEM

Field of the Invention

The present invention relates to a video projection system. More particularly, the present invention relates to a liquid crystal display (LCD) video projection system in which both polarizations of light are utilized to achieve greater brightness and efficiency.

Background of the Invention

A liquid crystal display projection system utilizes a liquid crystal modulator to form a primary image in a manner analogous to that of a slide in a slide projector. The primary image is then projected onto a screen or other display surface where it is easily viewed.

The liquid crystal modulator may be of the twisted nematic or field induced birefringence type. Either of these can modulate a polarization encoded image onto a linearly polarized input light beam. Both types rotate or re-orient an input linear polarization state by 90° at some pixel locations in the cross-section of the beam and pass the input polarization unchanged at other pixel locations in the cross-section of the beam. The encoded image formed by the modulator can thus be revealed by a polarizer which serves as an analyzer.
In a typical LCD projection system, an unpolarized light beam is first filtered to produce a linearly polarized light beam that is acted upon by a liquid crystal modulator. However, the resulting polarized light beam has less than half the intensity of the original unpolarized light beam. Thus, this kind of display is highly inefficient. Either an extremely high power source has to be used to produce the original unpolarized beam, or else, if a lower power source is utilized, the resulting image will have an unsatisfactory level of brightness.

An LCD projection system design, proposed by Seiko Epson Corp., is described in the May 12, 1986 issue of "Electronics". In this design, light that is polarized in only one of two orthogonal directions is modulated and projected onto a screen. To form the linearly polarized beam which is acted upon by the modulator, the system uses a polarizer of a type that absorbs more than 99% of the light with the unwanted polarization from an incident unpolarized light beam and approximately 20% of the light with the desired polarization from the incident light beam. Overall, a typical polarizer of this type transmits only about 40% of the unpolarized light beam. After passing through the liquid crystal modulator and the analyzing polarizer, at most about 32% of the original light remains, or even less if there are other losses.

It is possible to separate an unpolarized beam into two beams with orthogonal linear polarization states. It is also
possible to rotate the polarization state of one of the beams to agree with the polarization state of the other beam, but it is not possible to recombine those beams into a single high intensity linearly polarized beam. This principle is based on the second law of thermodynamics and cannot be violated.

A variety of systems have been proposed to circumvent this principle. For example, U.S. patent 4,127,322 describes (see FIG 4) an arrangement of polarizing elements and liquid crystal modulators that modulates light emitted from a source and projects the light onto a screen. The system comprises six electron-beam-addressed liquid crystal modulators. A polarizing beam splitter divides an unpolarized primary beam of white light into two orthogonally polarized beams. Each of the two polarized beams is then separated into three color beams using dichroic components. Each of the resulting six beams (three in each polarization) is then modulated by its own liquid crystal modulator so that a total of six modulators are required for use in this system. The six modulated beams are then recombined to form a single unpolarized beam for display on a screen. Because this system makes use of all the light produced by the source, the image is much brighter than that produced by a system which uses only one polarization. However, the system is highly complex and costly because it requires the use of six individual liquid crystal modulators. Thus, the use of this approach is limited to critical applications, where cost is not a factor.
Japanese Patent application No. 61-122626 discloses another approach to utilizing all of the light from a source in an LCD projection system. In this system, a polarizing beam splitter passes light of a desired polarization to a liquid crystal light modulator. The light component of the other polarization is reflected back towards the source, where the source's reflector reflects the light a second time. A quarter wave plate is interposed between the source and the beam splitter. The principle axes of the quarterwave plate are oriented at 45° to the states of polarization defined by the beam splitter. The light rejected by the beam splitter passes through the quarterwave plate twice, once in travelling from the beam splitter back to the source and once again after reflection by the mirror associated with the source. Thus, the rejected light has its polarization rotated 90° so that it finally emerges with the same polarization as the main beam. The converted beam is thereafter passed to the liquid crystal light modulator. This approach suffers from a number of deficiencies. First of all, the reflector associated with the source may not be 100% polarization preserving so that the system may not operate with maximum effectiveness. In addition, this approach treats the two polarizations unsymmetrically, introducing into the recycled beam extra reflections from two mirrors and many passes through glass-air interfaces at which unwanted reflections may occur.
U.S. patent 4,913,529 describes yet another approach to achieving higher brightness in an LCD video projection system. The system includes a polarizing beam splitter that splits a beam of collimated light from a light source into two orthogonally polarized beams. The beam of the desired polarization is refracted into a prism at a first face so that it reflects off a second face and exits the prism through a third face. The other beam with the non-desired polarization is passed through a device, such as a halfwave plate, that rotates its polarization 90°. Upon emerging from the device, the beam passes into the prism through its second face and exits the prism through the third face. Thus, both beams have the same polarization as they exit the prism through its third face. The two beams then pass through a liquid crystal modulator and are projected onto a screen. However, it is not possible for the two beams to travel in exactly the same direction as they exit from the third face. Consequently, this design introduces an asymmetry into the two beams so that it is difficult to achieve a good quality projected image.

Another LCD video projection system is disclosed in Imai et al, "High Brightness Liquid Crystal Light Valve Projector Using a New Polarization Converter", SPIE Vol. 1255, Large Screen Projection Display II (1990), pages 52–58. For this system, a primary beam is separated by a beam splitter into two orthogonally polarized beams. As in U.S. patent 4,913,529, the polarization state of one of the beams is then rotated 90°. It
is then attempted to combine the two linearly polarized beams, which, as indicated above, cannot be accomplished perfectly because of the second law of thermodynamics. The resulting combined beam is processed by a liquid crystal modulator and displayed on a screen. However, because of the problems in combining the two linearly polarized beams, it is difficult to obtain a good quality image.

In short, none of the prior art technique for achieving a higher brightness and efficiency in an LCD video projection system is entirely satisfactory. Accordingly, it is an object of the present invention to provide an improved LCD video projection system. More specifically, it is an object of the present invention to provide an improved LCD video projection system which achieves a higher brightness than conventional systems by utilizing light with both orthogonal polarization states. It is also an object of the present invention to provide an LCD video projection system which utilizes light of both orthogonal polarizations and a minimal number of optical components to achieve a high brightness projected image.

Summary of the Invention

In accordance with the present invention, a video image projection system uses both polarizations present in the illumination to achieve improved brightness and efficiency. The system divides an unpolarized light beam into first and second beams with first and second orthogonal linear
polarization states. Both polarized beams propagate along symmetric optical paths and are modulated by the same modulator. The modulator is connected to a source of a video image. Each beam is modulated, i.e., encoded with a video image, by changing or leaving unchanged the polarization state at specific locations in the beam cross-section corresponding to an array of pixel locations of the video image. The two modulated polarized beams are then analyzed and combined to form a single unpolarized beam whose cross-section is intensity modulated, e.g., specific locations in the beam cross-section are white or black depending on the pixel value of the video image at this location. The unpolarized but intensity modulated beam is then projected onto a screen to form an image.

Illustratively, the modulator is a liquid crystal modulator. (However, other modulators which selectively vary the polarization state of an input beam may be utilized, e.g., modulators based on the Pockels Effect or other electro-optic effects.) A polarizing beam splitter is utilized to divide the initial unpolarized beam into the first and second beams with first and second orthogonal polarizations. Optical components such as optical fibers or mirrors are used to define the first and second symmetrical optical paths for the first and second polarized beams. In particular, the two polarized beams are directed by those optical components to pass through the liquid crystal modulator in opposite directions. Each beam then
retraces the path of the other beam back to the beam splitter. At the beam splitter, the two polarization modulated beams are analyzed and recombined to form a single unpolarized beam whose cross-section is intensity modulated. The intensity modulated unpolarized beam is then displayed on a screen.

**Brief Description of the Drawing**

FIG 1 illustrates a liquid crystal modulator.

FIG 2 and FIG 3 illustrates a projection system in accordance with an illustrative embodiment of the present invention.

FIG 4 illustrates a projection system in accordance with the present invention which displays color images.

**Detailed Description of the Drawings**

FIG 1 illustrates a liquid crystal modulator. A liquid-crystal modulator can be used to rotate the state of polarization of light passing through it. The liquid crystal modulator 10 of FIG 1 comprises two transparent cover plates 112 and 114 with a nematic liquid crystal layer 116 in between. Each cover plate 112,114 has a thin transparent electrode layer 118,120 on its inside face adjacent to the nematic liquid crystal material 116. Typically indium-tin oxide is used for the electrodes. A very thin organic polymer is usually applied to the electrode layers for alignment purposes. Illustratively, the liquid crystal modulator 10 is an active
matrix device. One of the electrode layers, e.g., 120, is a planar back plate electrode and the other electrode layer, e.g., 118, comprises an array of pixel electrodes (not shown) corresponding to the pixel locations of a video image. Each pixel electrode has associated with it a field effect transistor (not shown). A signal voltage can be applied to the pixel electrode via the source-drain channel of the associated field effect transistor when an appropriate signal is applied to the gate electrode of the field effect transistor.

FIG 1 indicates the symmetry of the nematic liquid crystal layer 116 by a cylindrical rod 122. The nematic liquid crystal molecules are rod-shaped but, of course, they are of sub-microscopic dimensions. Near the surfaces of the nematic liquid crystal layer 116, the molecules tend to align with the direction in which the organic polymer alignment coatings are brushed. When the coatings are brushed at right angles to one another, and the space between the electrode layers 118,120 is filled with a liquid-crystal material 116 of an appropriate composition, the so-called 90° twisted nematic configuration results.

Using the rod 122, FIG 1 depicts that the direction of the molecules varies smoothly through the bulk of the nematic liquid crystal 116 between the directions (E, and E) at the surfaces of the electrode layers 118,120. The rod-like nematic liquid crystals have optical and dielectric anisotropies.
Light which is linearly polarized parallel to the long
dimension of the molecules has an index of refraction, \( n_c \),
which is different from the index of refraction, \( n_e \), of light
which is linearly polarized perpendicular to the molecules. If
the twist is slow enough, as expressed by the Mauguin limit
\[
\delta n d \gg \lambda, \quad (1)
\]
where \( \delta n = n_c - n_e \), and \( d \) is the thickness of the liquid
crystal, light entering at one surface polarized with its
electric field parallel to the local molecular alignment
rotates smoothly as it traverses the modulator and exits with
its polarization rotated by 90 degrees. If light is incident
from the other direction, the same process takes place and the
only difference is the sense of the rotation. Similarly, when
the light enters with polarization perpendicular to the
molecular alignment, 90 degree rotation occurs in either
direction. On the other hand, if an electric field is applied
to the nematic liquid crystal, the molecules align to the
field, for positive dielectric anisotropy, and the nematic
liquid crystal layer becomes optically isotropic. Thus, when
the field is applied, light emerges from the cell with the same
direction of polarization that it had when it entered.

Using the pixel electrodes, the electric field may be
selectively applied to various locations in the plane of the
nematic liquid crystal layer 116 corresponding to the pixel
locations of a video image. Therefore, the polarization state
of an incident linearly polarized beam may be changed at some locations in the beam cross-section and left unchanged at other locations in the beam cross-section so as to encode the beam cross-section with the pixels forming a video image. It should be noted that it is desirable to avoid applying a D.C. voltage to any pixel electrode. To avoid this, a D.C. bias voltage \(V_{bias}\) from source 190 is applied to the back plate electrode 120. If a pixel electrode is to be excited for a duration of multiple video frames, the voltage applied to this pixel is alternated between a value above and below the bias voltage. When the pixel is not to be excited, a voltage equal to the bias voltage is applied thereto. This scheme insures that there is no time average D.C. voltage on any pixel electrode. Thus, the voltage source for the pixel electrodes comprises the AC source 191 which produces the voltage \(V_{pixel}\) and a source 192 of a D.C. bias voltage \(V_{bias}\).

FIG 2 and FIG 3 illustrate an inventive LCD projection system 100 in accordance with the present invention. FIG 2 shows a planar view and FIG 3 shows a perspective view of the inventive LCD projection system makes use of the polarization-rotating modulator 10 of FIG 1.

An unpolarized beam light 23 is derived from a light source 20. The light source 20 comprises the reflector 201 and the condenser lens 22. Illustratively, the light source is an
arc discharge lamp. Thus, as shown in FIG 3, the light source also comprises an anode 203 and a cathode 204, which are supplied power via the lines 205 and 206 to generate a discharge. The light emitted by the discharge is reflected by the reflector 201 and is collimated by the condenser lens 22 to form the unpolarized beam of light 23.

The unpolarized beam of light 23 is directed to a first face 31 of the polarizing beam splitter 30. The polarizing beam splitter splits the unpolarized beam 23 into a first beam 24 with the P-polarization state, which passes straight through the beam splitter 30, and a second beam 27 with the S-polarization state, which is reflected from the diagonal boundary 35 within the beam splitter 30.

The first beam 24 exits from a second face 32 of the beam splitter 30. Beam folding element 40 directs the P-polarized beam 24 to a first side 11 of the modulator 10. In FIG 3, the beam folding element 40 is shown as being implemented as a planar mirror. Alternatively, the beam folding element 40 may be formed by a concave mirror. The beam folding element 40 of FIG 2 may also be formed by a bundle of polarization preserving optical fibers. In this case, the beam 24 is divided into a plurality of subbeams, each transmitted by one or more optical fibers and each corresponding to one pixel of the video image.

FIG 3 schematically illustrates the array of pixel electrodes 13 utilized in the liquid crystal modulator 10. The pixel electrodes 13 marked with an "x" (i.e., unexcited pixel
electrodes) serve to rotate the polarization of the arriving beam 24, while the unmarked (i.e., excited) pixel electrodes leave the polarization of the beam 24 unchanged. In this manner, polarization variations are used to encode the beam cross-section with a video image. As indicated above, each pixel electrode is associated with a field effect transistor not shown. The row select driver 302 applies signals to the gate electrodes of the field effect transistors. The column data driver 304 applies signals via the source to drain channels of the FETs to the pixel electrodes. A video signal source 306 such as a computer supplies video information to the drivers 302, 304.

Thus, as a result of processing by the modulator 10, portions of the cross-section of the beam 24 have an unchanged polarization and portions have a rotated polarization state.

In FIG 2, the path of beam 24 after processing by the modulator 10 is shown by a dashed line. After processing by the modulator 10, the beam folding element 40' redirects beam 24 to a third face 33 of the beam splitter 30. In FIG 3, the folding element 40' is shown as comprising a planar mirror; however, a concave mirror or a bundle of polarization preserving optical fibers may also be used. As shown in FIG 2, the portions of the beam 24 that retain the original P-polarization will pass straight through the beam splitter to emerge as beam 26 from the fourth face 34 of the beam splitter 30. The portions of beam 24 that emerge from the modulator 10
with $S$-polarization will reflect from the inner diagonal surface 35 of the beam splitter and emerge from the latter's first face 31 as beam 25. Beam 25 actually retraces the path of beam 23 back into the light source 20, but the two are shown as offset in FIG 2 in order to distinguish them from one another.

As shown in FIG 2, the second beam 27 with the $S$-polarization exits from the third face 33 of the beam splitter 30. Beam folding element 40' directs the $S$-polarized beam 27 to the second side 12 of the modulator 10. Upon traversing modulator 10, portions of the cross-section of beam 27 may remain $S$-polarized or may become $P$-polarized in the manner described above for the beam 24. In FIG 2, after processing by the modulator 10, beam 27 is illustrated by a dashed line. The beam folding element 40 redirects beam 27, after it exits the modulator 10, to the second face 32 of the beam splitter 30. The portions of beam 27 which retain the original $S$-polarization are reflected from the inner diagonal surface 35 of the beam splitter and emerge from the beam splitter's fourth face 34 as beam 28. The portions of beam 27 which emerge from the modulator 10 with $P$-polarization pass straight through the beam splitter 30 to emerge from the latter's first face 31 as beam 29. Beam 29 actually retraces the path of beam 23 back into the light source 20, but the two are shown as offset in FIG 2 in order to distinguish them from one another.
The light of beams 25 and 29 which is returned to the source is reflected in the light source effectively increasing the source output.

It should be noted that in FIG 2, the beams 24 and 27 actually retrace one another’s paths after exiting the polarization modulator 10. The paths are shown as offset from one another only for purposes of clarity. In addition, the beams 26 and 28 which emerge from the surface 34 of the beam splitter 30 are shown as offset in FIG 2 only for purposes of clarity. They actually trace the same path (so that they are aligned) and are combined to form a single unpolarized beam. The beam splitter 30 serves to analyze the two polarization encoded beams 24 and 27 so as to convert the polarization variations in the beam cross-sections into intensity variations in the cross-sections of the combined unpolarized beam 26, 28.

Specifically, if the modulator 10 is in its polarization rotating state at some pixel location, both beams 24 and 27 will have their polarization state rotated at this location, and consequently both beams will be directed back into the light source 10 at this pixel location. The pixel location in question will be dark in the cross-section of the combined beam 26, 28. Light in both beams 24 and 27 passing through some other pixel location of the modulator 10 where the modulator is set to its non-rotating state will be bright in the cross-section of the combined unpolarized beam 26, 28. A pattern of polarization rotating and non-rotating pixels defined over the
active area of the modulator 10, in response to its electrical inputs, will result in a pattern of bright and dark pixels in the cross-section of the combined beam 26,28 emerging from the surface 34 of the beam splitter 30. In being directed towards the output at face 34 of the beam splitter 30, beam 27 is reflected from the boundary 35 while beam 24 passes straight through the boundary 35. The images encoded on the two beams at the modulator 10 are superimposable, however, because they emerge from opposite sides of the modulator and this difference is equivalent to a second reflection.

The superimposed beam formed by the beams 26 and 28 is projected by the projection lens 50 onto the screen 60 to form the video image thereon.

The projection system of FIGs 2 and 3 has a number of advantages. Light that passes through the modulator 10 at places where the image is to be dark flows back into the light source as beams 25 and 29. Depending on the nature of the light source, some of that could be returned by the reflector 21 to illuminate bright areas in the image. But even if beams 25 and 29 are absorbed, it is advantageous to return the rejected light to the light source rather than to heat some other component in the system. Because the system has no absorbing components, it could be made smaller than other systems in which a temperature rise of optical elements affects the design. The inventive system also modulates the two polarizations completely symmetrically and does not need extra
components which might cause unwanted reflections, as some prior art systems do. Reflections do exist, however, because the beams 24 and 27 pass through the beam splitter 30 twice. One way to suppress all reflections is to use coherent fiber-optic bundles to form the beam folding elements 40 and 40' to convey the beams from the beam splitter 30 to the modulator 10 and back. This would also shorten the back focal distance from the projection lens 50 to the images formed in beams 26 and 28 because the fiber-optic bundles bring the images forward from the modulator 10 to faces 32 and 33 of the beam splitter 30. However, polarization-maintaining fibers would be required and the cost may be higher than for system designs that use optical paths in air.

The inventive liquid crystal display video projection system may be utilized to display color video images. A color video projection system 300 which incorporates the principles of the present invention is illustrated in FIG 4. A light source 302 generates a beam 304 of unpolarized white light. The dichroic mirrors 306 and 308 are used to form the unpolarized blue, green and red beams 310, 312 and 314 from the white beam 304. The unpolarized blue beam 310 is directed to the modulation system 320. The unpolarized green beam 312 is directed to the modulation system 330. The unpolarized red beam 314 is directed to the modulation system 340.

Each of the modulation systems 320, 330, 340 is of the type shown in FIGs 2 and 3 and whose operation has been
described in detail above. Thus the blue modulation system 320 comprises the polarizing beam splitter 421 and the liquid crystal modulator 422. Similarly, the modulation system 330 comprises the polarizing beam splitter 431 and the liquid crystal modulator 432 and the modulator system 340 comprises the polarizing beam splitter 441 and the liquid crystal modulator 442. More particularly, each modulation system 320, 330, 340 receives an unpolarized blue, green or red beam of light. A polarizing beam splitter separates the unpolarized beam of blue, green, or red light into first and second orthogonally linearly polarized beams. The first and second linearly polarized beams of each color propagate along first and second symmetric optical paths which includes a single liquid crystal modulator. The single liquid crystal modulator transmits the two beams in opposite directions while modulating the beam cross-sections with polarization variations corresponding to the pixels of a video image. The two beams are then returned to the beam splitter, wherein the two polarization modulated beams are analyzed and combined into a single unpolarized beam whose cross-section is intensity modulated with a video image.

Thus, the outputs of the blue, green and red modulator systems 320, 330, 340 are unpolarized blue, green and red beams 322, 332, 342, all of which have cross-sections which are intensity modulated with the pixels of a video image. The beams 322, 332 and 342 are modulated in the manner described
above in accordance with the present invention and thus comprise light of both polarizations.

The beams 322, 332, and 342 are combined using the dichroic mirrors 350 and 352 to form a single beam 360. The projection lens 370 projects the beam 360 onto the screen 380 so that a video image can be viewed.

Finally, although the present invention has been described in conjunction with preferred embodiments, it is to be understood that modifications and variations may be realized without departing from the spirit and scope of the invention, as those skilled in the art would readily understand. Such modifications and variations are considered to be within the purview and scope of the invention and the appended claims.
CLAIMS

1. A video projection system for displaying a video image comprising
   a source of a video image,
   a source of a beam of unpolarized light,
   means for dividing the beam of unpolarized light into first and second beams with first and second orthogonal polarizations,
   means for forming first and second symmetric optical paths for said first and second beams, said first and second optical paths including a single modulator connected to said video image source for polarization modulating the cross-sections of both said first and second beams with polarization variations corresponding to an array of pixels of said video image, and
   means for receiving said first and second beams via said first and second optical paths after modulation by said modulator and for converting said polarization modulated first and second beams into an unpolarized beam whose cross-section is intensity modulated with said video image.

2. The projection system of claim 1 wherein said projection system comprises
   means for projecting said unpolarized intensity modulated beam onto a screen to display said video image.

3. The video projection system of claim 1 wherein said modulator is a liquid crystal modulator.
4. The video projection system of claim 1 wherein said first and second beams pass through said liquid crystal modulator in opposite directions.
5. The video projection system of claim 4 wherein said means for defining first and second optical paths comprises first and second mirrors for directing said first and second beams to said liquid crystal modulator in opposite directions.
6. The video projection system of claim 5 wherein said mirrors are planar.
7. The video projection system of claim 4 wherein said first and second beams comprise a plurality of sub-beams with each sub-beam corresponding to one pixel of said video image, each sub-beam of said first and second beams being transmitted along said first and second optical paths at least in part by an individual optical fiber.
8. The video projection system of claim 1 wherein said means for dividing and said means for receiving and for converting comprise a single polarizing beam splitter.
9. A method for displaying a video image comprising the steps of
   (1) dividing an unpolarized beam of light into first and second beams having first and second orthogonal polarizations,
   (2) directing said first and second beams along first and second symmetric optical paths including a single modulator,
(3) applying said video image to said modulator,

(4) modulating cross-sections of both said first and second beams with polarization variations in response to said video image to produce polarization modulated first and second beams,

(5) combining said first and second polarization modulated beams to form an unpolarized beam whose cross-section is intensity modulated with a video image, and projecting said unpolarized intensity modulated beam to display said video image.

10. The method of claim 9 wherein said dividing and combining steps are performed using a single polarizing beam splitter.

11. A system for displaying a video image comprising:

a source of a video image,

a source of a beam of unpolarized light,

a polarizing beam splitter for dividing the beam of unpolarized light into first and second beams with first and second orthogonal polarizations, and

first and second equal-distance optical paths for said first and second beams including a single modulator connected to said video source for modulating the cross-sections of both said beams with polarization variations corresponding to pixels of said video image, said polarizing beam splitter combining said first and second beams to form an
unpolarized beam having a cross-section which is intensity modulated with said video image.

12. The system of claim 11 further including means for projecting said unpolarized intensity modulated beam to display said video image.

13. The system of claim 11 wherein said modulator is a liquid crystal modulator.

14. The system of claim 11 wherein said system is incorporated in a system for displaying a color video image.

15. The system of claim 1 wherein said system is incorporated in a system for displaying a color video image.

16. A system for displaying a video image comprising a source of a video image, a source of a beam of light, optical means for intensity modulating said beam of light with said video image by removing light from said beam at selected locations in the cross-section of said beam, and for returning to said source the light removed from said beam, and means for displaying a video image formed using the intensity modulated beam.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
   IPC(S) :G02F 1/13
   US CL. :353/34,31 30; 359/40,42,48
   According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
   Minimum documentation searched (classification system followed by classification symbols)
   U.S. : 353/30,33,37,81,82,20,122; 359/37,70,495,496,629,643,638
   Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X,P</td>
<td>US, A, 5,181,054, NICOLAS ET AL, 19 January, See Figure 1a,1b,9</td>
<td>1-6,8-16</td>
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<td>7</td>
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<tr>
<td>A,P</td>
<td>Electronics Letters, Vol. 25 No.2, pp. 119-121, Published 1989, January 19, &quot;Polarization-Independent Lightwave Switch/Modulator at 820 and 1300 nm for Fiber Optic Systems&quot;, CHANG ET AL, See Figure 1</td>
<td>7</td>
</tr>
</tbody>
</table>

- Special categories of cited documents:
  - "A" document defining the general state of the art which is not considered to be part of particular relevance
  - "E" earlier document published on or after the international filing date
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  - "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principles or theory underlying the invention
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  - "Z" document member of the same patent family

Date of the actual completion of the international search: 17 June 1993
Date of mailing of the international search report: 29 JUL 1993

Name and mailing address of the ISA/US Commissioner of Patents and Trademarks
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Form PCT/ISA/210 (second sheet)(July 1992)