ELECTRO-OPTIC STORAGE DEVICE

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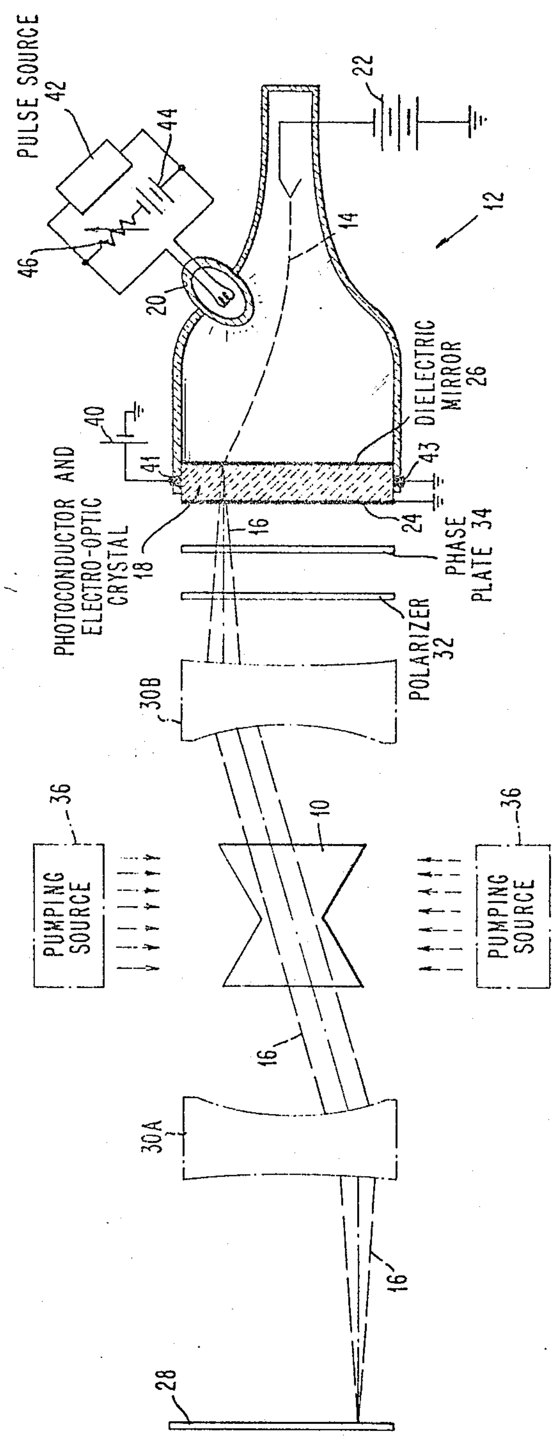

FIG. 1

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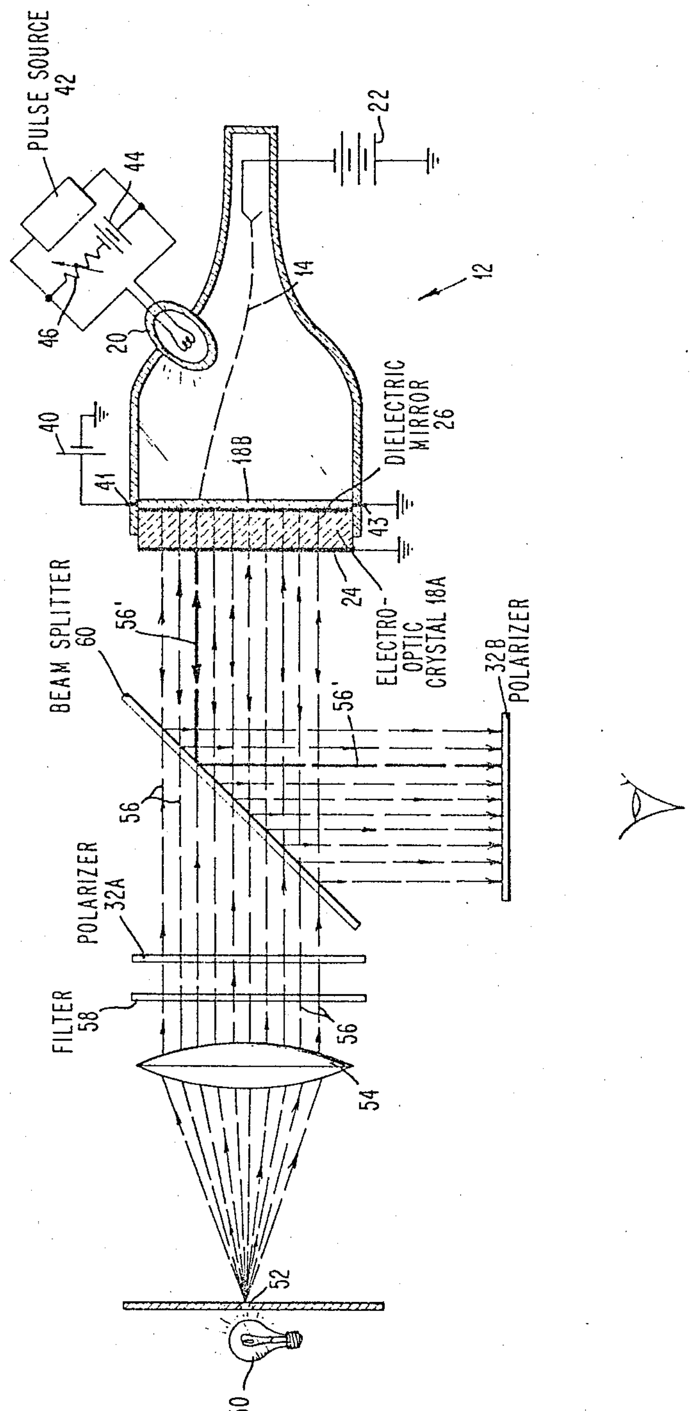
FIG. 2


PULSE SOURCE 42
44
22
12
14
46
20
40
41
18B
DIELECTRIC MIRROR 26
43
24
ELECTRO-OPTIC CRYSTAL 18A
BEAM SPLITTER 60
56'
56
32B POLARIZER
POLARIZER 32A
FILTER 58
54
52
50

3,445,826

ELECTRO-OPTIC STORAGE DEVICE

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U.S. Cl. 340—173 10 Claims

This invention relates to optical apparatus, and more particularly to devices which exhibit electro-optic effects in response to charge patterns deposited thereon.

The electro-optic effect has been employed to convert an electric field pattern into a pattern of light. Often the material exhibiting the electro-optic effect is illuminated with polarized light, and the plane of polarization is altered in accordance with the field pattern. The field may be created for example, in a cathode ray tube wherein a beam of electrons is directed against a face composed of electro-optic material. While the electron beam can be moved very rapidly across the face of the tube, the charge pattern deposited thereon cannot be rapidly erased to permit a new pattern to be displayed.

Flood guns may be employed in the cathode ray tube to erase the charge pattern from the face by heavy bombardment of electrons of the proper energy and consequent secondary emission from the face. However, such flood guns require the presence of an additional grid near the face of the tube to carry off the secondary emission charge, interfering with the primary electron beam which must pass through the grid. Also, the flood gun adds a considerable amount of hardware to a cathode ray tube.

Accordingly, it is an object of the present invention to provide an electro-optic device capable of rapid changes.

Another object of the present invention is to provide an improved electro-optic device capable of rapidly erasing charge patterns deposited thereon.

Still another object of the present invention is to provide a cathode ray tube having an electro-optic face and capable of rapid erasure of the electron beam charge deposited thereon.

A further object of the present invention is to provide an improved electro-optic device having the ability to erase charge patterns stored thereon without interfering with the resolution of the charge pattern deposited thereon.

It is another object of the present invention to provide an electro-optic device capable of storing a charge pattern thereon for a variable period of time.

Another object of the present invention is to provide apparatus for use in laser mode selection.

These and other objects of the present invention are accomplished by providing an electro-optic device which also exhibits a photoconductive effect. The charge pattern deposited on the device is erased by illumination.

In accordance with one aspect of the present invention, a source of polarized light is directed onto the device exhibiting a photoconductive and electro-optic effect. The frequency range of the polarized light is selected to be outside the range of frequencies capable of producing a photoconductive effect in the device. On the other hand, the source of illumination used to erase the charge pattern is selected to be within the range of frequencies causing the device to be conductive.

In this manner, there is no interference with the deposition of charge on the electro-optic device. If an electron beam is used to deposit the charge pattern, the source of illumination for erasure purposes may be located out of the way of the electron beam. Further, since erasure is accomplished using a photoconductive effect instead of a secondary-emission effect, the deposited charge may be carried off without the use of an additional grid interfering with the resolution of the device.

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention, as illustrated in the accompanying drawings.

In the drawings:

FIG. 1 is a diagram illustrating an electro-optic device employing the present invention to control the direction of emission of laser light; and

FIG. 2 is a diagram illustrating another embodiment of the present invention employed in a display system.

In the apparatus of FIG. 1, the direction of emission of laser light from a ruby 10 is controlled by a cathode ray tube 12. An electron beam 14 selects one of a plurality of angular modes of oscillation represented by a mode 16 in FIG. 1.

Laser emission occurs along the mode of oscillation 16 due to the electro-optic effect in a crystal 18. At the location where electron beam 14 strikes the crystal 18, a charge is deposited setting up a field across crystal 18 which alters the refractive indices of the crystal 18 at this point.

A lamp 20 is employed to discharge the field set up across crystal 18. The material of crystal 18 is selected to exhibit a photoconductive effect in response to the illumination of lamp 20. When lamp 20 is activated, the charge deposited by beam 14 is drained off erasing the field and thereby extinguishing the preferred mode of oscillation 16.

Detailed description of embodiment in FIG. 1

Cathode ray tube 12 operates in a conventional manner. A battery 22 supplies the acceleration voltage for beam 14. On the outer surface of crystal 18, a transparent coating 24 of stannous oxide (SnO) provides a ground reference for electron beam 14. A dielectric mirror coating 26 is applied to the inner surface of the crystal 18 forming one end of a laser cavity. The other end of the laser cavity is formed by a mirror 28.

A pair of lenses 30A and 30B focus the angularly oriented mode of oscillation 16 on the reflecting surfaces 28 and 26 respectively. Other modes of oscillation (not shown) similar to modes 16, but rotated about the center of laser 10 are also focused on the reflecting surfaces 28 and 26 by lenses 30A and 30B respectively. One specification for lenses 30A and 30B may be found in commonly assigned co-pending application Ser. No. 511,775, filed Dec. 6, 1965 entitled, Lens Group Employed in Laser Cavities, by R. E. Tibbetts and J. S. Wilczynski.

A polarizer 32 is placed in the path of all modes of oscillation to transmit light only with a single axis of polarization. A fixed optical retardation plate 34 introduces a relative phase delay between orthogonal polarization components of light passing therethrough. The plate 34 is arranged so that the two orthogonal components are oriented at 45 degrees with respect to the polarizer 32. In a like manner, the crystal 18 is oriented so that its electrically induced principal axes are oriented at 45 degrees to the polarizer 32. Reference may be made to commonly assigned co-pending application Ser. No. 412,814, entitled Apparatus for Controlling a Laser Beam by R. V. Pole and R. A. Myers, for further details of the polarizer 32 and plate 34, as well as for a more detailed description of the operation of the laser cavity than a general description to follow.

In operation, a pumping source 36, typically a helical flash tube, stimulates laser 10 so that light is produced along a large number of angularly oriented modes of oscillation, such as mode 16. The light passing through polarizer 32 is limited to a single polarization axis. After passing through polarizer 32 and retardation plate 34, a phase delay exists between two orthogonal components of the light. After reflection from mirror 26, the light undergoes an additional phase delay passing through plate 34 and a portion thereof is blocked by polarizer 32, which acts as an analyzer for this light returning to laser 10.

The phase delay introduced by plate 34 is selected so that the intensity of the light returning to laser 10 is insufficient to cause the laser to oscillate and emit its characteristic light in response to pumping source 36. In order to obtain laser emission, the phase delay introduced by plate 26 must be compensated for by an opposite phase delay introduced by crystal 18. This is accomplished by the deposition of a charge on crystal 18 producing a field across crystal 18. This field in turn produces an electro-optic effect in crystal 18 altering the polarization of the light passing therethrough to compensate for the retardation introduced by plate 34. Therefore, with the electron beam 14 in the position shown in FIG. 1, laser 10 emission occurs along the mode 16 passing out of the cavity through partially transmitting reflector 28.

Laser emission along other modes of oscillation may be achieved by moving the position of electron beam 14. However, the charge placed upon crystal 18 must be removed if emission along mode 16 is no longer desired. Crystal 18 stores the charge placed thereon for a period of time determined by its characteristic ability to conduct the charge through to the ground potential coating 24. Crystal 18 may be composed of several different types of materials, such as zinc sulphide (ZnS), gallium arsenide (GaAs), gallium phosphide (GaP), silicon carbide (SiC), and zinc telluride (ZnTe). Crystals of these materials, and others, may be doped with impurities to alter their conductive property, and are referred to as semi-conductors. Therefore, the storage time of the charge placed on the crystal 18 by electron beam 14 may be varied by doping the crystal in a manner well known in the semi-conductor art. This storage time is characteristic of the crystal 18 and permanently installed during manufacture thereof.

In order to change the storage time of the crystal 18, lamp 20 is provided. The illumination from lamp 20 is selected to be in the range of frequencies producing a photoconductive effect in crystal 18. Each of the materials listed above exhibits a photoconductive effect for certain frequencies of light. This effect may be enhanced by adding impurities to the crystal 18 during manufacture in accordance with well known techniques in the art. Assuming crystal 18 is made of a zinc sulphide (ZnS) material, lamp 20 provides illumination in the ultraviolet region. Therefore, the light from the ruby laser 10, typically in the red frequency range, does not produce a photoconductive effect in the crystal 18, while the ultraviolet illumination from lamp 20 causes a large change in the conductivity of crystal 18. The ratio of the light and dark conductivity may be made up to 10^6:1.

When illuminated the crystal 18 conducts the charge deposited on the side by beam 14 through to the grounded coating 24. Alternatively, a battery 40 connected by an electrode 41 to the upper portion of crystal 18, and another electrode 43 connected to ground may be employed to drain off the charge when crystal 18 becomes conductive. By arranging the electrodes 41 and 43 as shown in FIG 1, the field produced thereby is transverse to the field produced by electron beam 14 and may be oriented so it does not alter the operation of the polarized laser light.

The lamp 20 may be operated in a variety of manners. One example is shown in FIG. 1, where a pulse source 42 is connected across the lamp 20 to provide a short burst of illumination. The pulse source 42 may be used where an entire pattern is drawn on the crystal 18 by moving the beam 14. Prior to drawing another complete pattern pulse source 42 provides a burst of illumination from lamp 20 which erases the entire pattern. This operation is similar to successive frames in a motion picture system.

Still another method of operation can be performed by a battery 44 and variable resistor 46. In this case, the lamp 20 provides a constant illumination increasing the inherent conductivity built into the crystal 18 during manufacture. Therefore, if it is desired to increase the storage time of crystal 18, then variable resistor 46 may be increased resulting in a decreased illumination, causing a corresponding increase in the storage time of crystal 18. Therefore, in the system of FIG. 2, the storage time may be varied by adjusting the constant illumination of lamp 20, and additionally by activating pulse source 42 for complete erasure.

Detailed description of embodiment in FIG. 2

Like numerical designations are applied to the same elements in both FIGS. 1 and 2. One modification is the addition of a layer 18B exhibiting photoconductive effects to the back of mirror 26. A crystal 18A in the same position as crystal 18 exhibits only the electro-optic effect. This permits the selection of different materials for crystal 18A and layer 18B. For example, crystal 18A may now be composed of potassium dihydrogen phosphate (KDP) which does not exhibit a photoconductive effect.

Another difference in FIG. 2 is the source of polarized light which includes a lamp 50, passing light through an aperture 52. A lens 54 collimates the light into parallel rays represented by a group of rays 56 in FIG. 2. A filter 58 and polarizer 32A pass light of a single frequency and single polarization. The light rays 56 continue through a beam splitter 60, through the crystal and are reflected back off the beam splitter. Before being viewed, the light passes through a second polarizer 32B, crossed with respect to polarizer 32A. Therefore, in the absence of a field pattern across the electro-optic crystal 18A, the viewer sees no light. The light pattern reaching the viewer corresponds to the charge pattern deposited by electron beam 14.

Lamp 20 operates in the same manner as described with regard to FIG. 1. Layer 18B becomes conductive when lamp 20 is illuminated by pulse source 42 thereby draining off the charge pattern.

The embodiments of FIGS. 1 and 2 illustrate two of the many possible light sources, laser 10 and lamp 50, which may be employed in the present invention. Further, the photoconductive effect and the electro-optic effect can be contained in a single crystal 18, or can be ememployed in the present invention using two materials 18A and B.

Still another modification can be made to the embodiment of FIG. 2 where a type of cathode ray tube is employed having the source for electron beam 14 located off center and out of the path of rays 56. For this modification, the observer views the light pattern from behind the cathode ray tube 12 and the necessity of a beam splitter 60 and mirror 26 is removed.

While both embodiments shown in FIGS. 1 and 2 employ a cathode ray tube 12 to deposit a charge pattern, many other devices may be employed to set up a field across the crystals 18 such as a metallic matrix on the back of the crystal 18, connected to a control source.

While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that the foregoing and other changes in form and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. An electro-optic device comprising:
storage means exhibiting electro-optic and photoconductive effects;
charging means for depositing a charge pattern on said storage means to alter the refractive index of portions thereof; and
control means for illuminating said storage means to

alter the conductivity thereof and to control the discharge of said deposited pattern.

2. Apparatus as defined in claim 1 wherein said charging means includes means for directing an electron beam against said storage means.

3. Apparatus as defined in claim 1 wherein said control means includes a light source of variable intensity.

4. Apparatus as defined in claim 3 wherein said charging means includes means for directing an electron beam against said storage means.

5. Apparatus as defined in claim 1 further characterized by the addition of a source of polarized light directed at said storage means and composed of a range of frequencies having substantially no photoconductive effect on said storage means whereby the electro-optic effect of said storage means alters the polarization of said polarized light in accordance with said charge pattern.

6. Apparatus as defined in claim 5 wherein said source includes a laser cavity having a plurality of modes of oscillation, and at least one reflecting surface located behind said storage means to cause said modes of oscillation to pass through said storage means, whereby the mode of laser emission is selected by the position of the deposited charge.

7. An electro-optic device comprising:

a cathode ray tube having a face composed of a material exhibiting an electro-optic and photoconductive effect; and

control means for illuminating said face to alter the conductivity thereof.

8. Apparatus as defined in claim 7 wherein said control means includes a source of light of variable intensity having frequency components within a range of those capable of producing a photoconductive effect in said cathode ray tube face.

9. Apparatus as defined in claim 8 further characterized by the addition of a source of polarized light directed at said face and composed of frequencies outside said range causing substantially no photoconductive effect in said face, whereby operation of said cathode ray tube alters the refractive index of portions of said face producing a corresponding alteration in the polarization of said polarized light.

10. Apparatus as defined in claim 8 wherein said source includes a laser cavity having a plurality of modes of oscillation, and at least one reflecting surface located on the inner side of said face to cause said modes of oscillation to pass through said face, whereby the mode of laser emission is selected by the operation of said cathode ray tube.

References Cited

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TERRELL W. FEARS, *Primary Examiner.*

U.S. Cl. X.R.

250—213; 313—65; 315—18; 331—94.5; 340—174.1; 356—117