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(54) Title: ELECTRONIC ALIGNMENT OF ACOUSTO-OPTIC MODULATOR FOR MODULATING A LASER
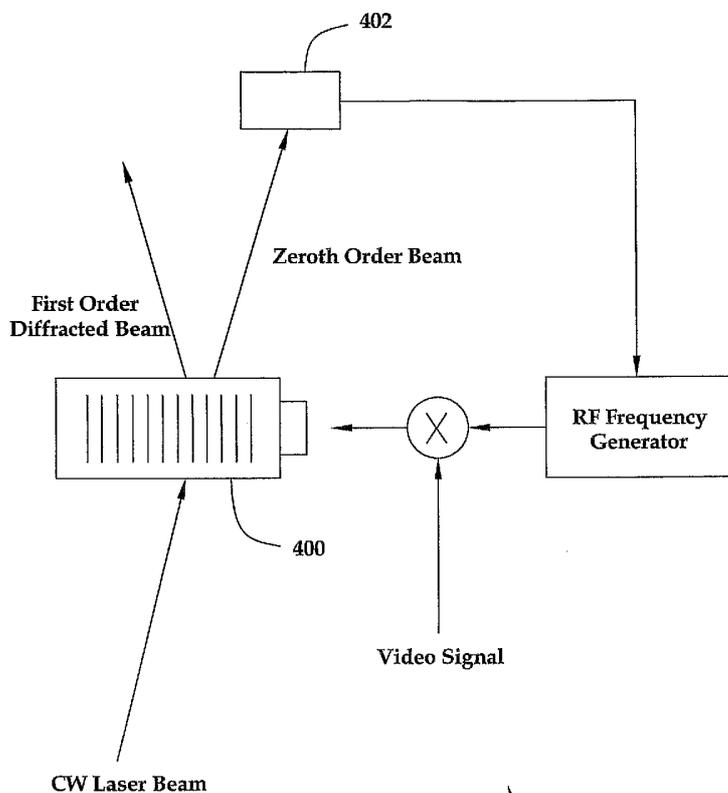
(57) Abstract: A method and apparatus are provided to modulate a beam of laser light. An acoustooptic modulator (AOM400) is positioned to receive continuous-wave (CW) laser light at an angle approximating the Bragg angle. Fine tuning of the modulation is then used to compensate for any variations in the actual angle from the Bragg angle. A photodiode (402) provides a feedback signal that may be used to tune or adjust the operation of the AOM. The photodiode is positioned to receive laser light at the first or zero order diffraction and provide a signal indicative of the magnitude of the first or zero order diffraction laser light produced by the AOM. The photodiode signal is coupled to an RF frequency generator so that the RF frequency may be adjusted to vary the acoustic wave in the AOM to compensate for any variations in the Bragg angle.

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For two-letter codes and other abbreviations, refer to the "Guid-ance Notes on Codes and Abbreviations" appearing at the begin-ning of each regular issue of the PCT Gazette.

ELECTRONIC ALIGNMENT OF ACOUSTO-OPTIC MODULATOR FOR MODULATING A LASER

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

5   This invention relates generally to electronic displays, and, more particularly, to a multi-color Laser Projection Display (LPD).

2. DESCRIPTION OF THE RELATED ART

10   Single-color or monochrome LPDs have been implemented using a raster-based scanning system. A raster-based LPD uses a laser and oscillating mirror(s) that move in horizontal and vertical directions to scan the laser light over a viewing screen in a raster pattern. By controllably modulating the laser in time with the movements of the mirror(s), a two-dimensional image can be produced. In fact, the LPD can produce a high quality image,

15   such as VGA or higher resolution by modulating the mirrors at frequencies in the range of 10's and 100's of MHz.

Monochrome displays, however, have limited utility, whereas full color displays are in wide use and are desired and accepted by the general public. Full-color LPDs may be produced by controllably combining red, blue and green laser light to produce a wide spectrum

20   of colors. Generally, red, blue and green lasers are commercially available, but not in small-form factors, such as semiconductor laser diodes. In fact, while semiconductor laser diodes that emit in red and blue wavelengths are available and can be directly modulated, there is no commercially available semiconductor laser that emits in the green wavelength. It is advantageous to use a green laser since having red, green, and blue wavelengths enable a true

25   full-color display. Also, human vision is more sensitive to green. Thus, for the same emitted laser power, a brighter display is perceived if green laser light is included.

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The present invention is directed to overcoming, or at least reducing, the effects of one

or more of the problems set forth above.

SUMMARY OF THE INVENTION

5   In one aspect of the instant invention, a method is provided for modulating laser light.

The method comprises delivering laser light to an optic modulator at an angle generally

incident at the Bragg angle relative to the optic modulator and adjusting the operation of the

optic modulator to compensate for at least   deviation of the laser light from the

Bragg angle.

10   In another aspect of the instant invention, a method is provided for modulating laser

light. The method comprises delivering laser light to an optic modulator at an angle generally

incident at the Bragg angle relative to the optic modulator and adjusting the optic modulator to

produce a desired characteristic of laser light of at least one ordered diffraction.

In yet another aspect of the instant invention, an apparatus is provided for modulating

15   laser light. The apparatus comprises a source of laser light, an optic modulator, a sensor and a

controller. The optic modulator is arranged to receive laser light at an angle generally incident

at the Bragg angle relative to the optic modulator. The sensor is adapted to measure a

characteristic of laser light of at least one ordered diffraction produced by the optic modulator.

The controller is adapted to adjust the operation of the optic modulator to compensate for at

20   least a portion of a deviation of the laser light from the Bragg angle.

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BRIEF DESCRIPTION OF THE DRAWINGS

The invention may be understood by reference to the following description taken in conjunction with the accompanying drawings, in which like reference numerals identify like

5   elements, and in which:

Figure 1 is a stylistic block diagram of a top level view of one embodiment of the present invention;

Figure 2 is a stylistic view of a viewi   wn in Figure 1;

Figures 3A and 3B depict a top view of a scanning device at various times during its

10   operation; and

Figure 4 depicts one embodiment of an alignment set up using a photodiode to measure the power in the diffracted laser beam, and using the photodiode signal to tune the RF frequency.

While the invention is susceptible to various modifications and alternative forms,

15   specific embodiments thereof have been shown by way of example in the drawings and are herein described in detail. It should be understood, however, that the description herein of specific embodiments is not intended to limit the invention to the particular forms disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

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DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

Illustrative embodiments of the invention are described below. In the interest of clarity, not all features of an actual implementation are described in this specification. It will of course be appreciated that in the development of any such actual embodiment, numerous

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implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort might be complex and time-consuming, but would nevertheless be a routine undertaking for

5   those of ordinary skill in the art having the benefit of this disclosure.

The following co-pending applications are hereby incorporated by reference herein in their entirety: Method and Apparatus for Aligning a Plurality of Lasers in an Electronic Display Device, by Mik Stern et. al.; Meth(us for Controllably Reducing Power Delivered by a Laser Projection Display, by Mik Stern et. al.; Method and Apparatus for

10   Displaying Information in Automotive Applications Using a Laser Projection Display, by Narayan Nambudiri et. al.; Method and Apparatus for Providing an Interface Between a Liquid Crystal Display Controller and a Laser Projection Display, by Narayan Nambudiri et. al.; A Color Laser Projection Display by Paul Dvorkis et. al.; Method and Apparatus for Capturing Images Using A Color Laser Projection Display, by Chinh Tan et. al.; A Laser Projection

15   Display, by Ron Goldman et. al.; Method and Apparatus for Controllably Compensating for Distortions in a Laser Projection Display, by Carl Wittenberg et. al.; and Method and Apparatus for Controllably Modulating a Laser in a Laser Projection Display, by Dmitriy Yavid et. al.

Turning now to the drawings, and specifically referring to Figure 1, a stylistic block

20   diagram of a laser projection display (LPD) 100, in accordance with one embodiment of the present invention, is shown. In the illustrated embodiment, the LPD 100 includes three lasers 102, 104, 106, each capable of emitting a beam of light 108, 110, 112 consisting of a unique color, such as red, green or blue. Those skilled in the art will appreciate that the number of

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lasers and the color of light emitted therefrom may be varied without departing from the spirit

and scope of the instant invention.

The lasers 102, 104, 106 are arranged in a common plane 114 with the beams of light

108, 110, 112 being angularly directed relative to one another to fall on a substantially

5   common location 116 on a first scanning device, such as a first scanning mirror 118, from

where they are reflected as beams of light 120, 122, 124. In the illustrated embodiment, the

first scanning mirror 118 oscillates on an axis 120 at a relatively high rate (e.g., about 20-30

KHz). Rotation or oscillation of the first s   · 118 causes the beams of light 108,

110, 112 to be moved. That is, as the angular position of the first scanning mirror 118 alters,

10   so to does the angle of reflection of the beams of light 120, 122, 124 from the first scanning

mirror 118. Thus, as the mirror oscillates the reflected beams of light 120, 122, 124 are

scanned to produce movement of the beams of light 120, 122, 124 along one component of the

two-dimensional display.

The second component of the two-dimensional display is produced by a second

15   scanning device, such as a mirror 126. In the illustrated embodiment, the second mirror 126 is

coupled to a motor 128 at a pivot point 130 so as to produce rotational or oscillating movement

about an axis that is substantially orthogonal to the axis of rotation of the first mirror 118. The

beams of light 120, 122, 124 are reflected off of the second mirror 126 as beams of light 132,

134, 136 and directed to a viewing surface 138. The viewing surface 138 may take on any of a

20   variety of forms without departing from the spirit and scope of the instant invention. For

example, the viewing surface 138 may be a fixed screen that may be front or back lit by the

lasers 102, 104, 106 and may be contained in a housing (not shown) that is common with the

LPD 100, or alternatively, the viewing surface 138 may take the form of any convenient,

generally flat surface, such as a wall or screen, spaced from the LPD 100.

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The second mirror 126 oscillates or rotates at a relatively slow rate, as compared to the rate of the first mirror 118 (e.g., about 60 Hz). Thus, it will be appreciated that, as shown in Figure 2, the beams of light 132, 134, 136 generally follow a path 140 on the display surface 138. Those skilled in the art will appreciate that the path 140 is similar in shape and concept to

5   a raster scan commonly employed in cathode ray tube televisions and computer monitors.

While the instant invention is described herein in the context of an embodiment that employs separate first and second scanning mirrors 118, 126, those skilled in the art will appreciate that a similar path 140 may be pr   g a single mirror. The single mirror would be capable of being moved about two axis of rotation to provide the fast and slow

10   oscillating movements along two orthogonal axes.

As is apparent from Figure 1, owing to the angular positioning of the lasers 102, 104, 106, even though the lasers 102, 104, 106 have been arranged mechanically and optically to deliver the beams of light 108, 110, 112 within the same plane 114 and at the same point (on the rotational axis 120) on the mirror 118), each has a different angle of reflection, which

15   causes the beams of light 120, 122, 124 to diverge. A controller 142 is provided to controllably energize the lasers 102, 104, 106 to effectively cause the beams of light 120, 122, 124 to be collinear, such that they may be reflected off of the second mirror 126 and delivered to the same point on the viewing surface 138 relatively independent of the distance of the viewing surface 138 from the second mirror 126.

20   Turning now to Figures 3A and 3B, the operation of the controller 142 to cause the beams of light 120, 122, 124 to be collinear is discussed. To simplify the discussion, only two lasers 102, 104 are illustrated in Figure 3, but those skilled in the art will appreciate that the concepts discussed herein may be extended to three or more lasers without departing from the spirit and scope of the instant invention. As shown in Figure 3A, if the lasers 102, 104 are

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energized simultaneously, the reflected beams of light 120, 122 diverge. However, as shown in

Figure 3B, if the lasers 102, 104 are energized at slightly different times, then the beams of

light 120, 122 can be made to follow a single, common path (i.e., the beams of light 120, 122

are collinear). For example, if the laser 102 is energized at a first time t1, then the mirror 118

5   will be at a first position, as represented by the solid lines, and the beam of light 108 will

reflect off of the mirror 118 as the beam of light 120. Subsequently, if the laser 104 is

energized at a second time t2, then the mirror 118 will be at a second position, as represented

by the dashed lines, and the beam of light 1   off of the mirror 118 as the beam of

light 122. By precisely controlling the time t2, the mirror 118 will be in a position to

10   accurately reflect the beam of light 122 along substantially the same path as the beam of light

120.

        Thus, through the operation of the controller 142, the beams of light 120, 122 are

substantially collinear, but are slightly displaced in time. That is, the beams of light 120, 122

will now both be projected onto substantially the same point on the display surface 138, but at

15   slightly different times. However, owing to the persistence of the human eye, the variation in

timing is not detectable. That is, in the case of the three laser system described in Figure 1,

each of the lasers 102, 104, 106 will controllably deliver laser light of a unique color and

intensity to substantially the same point on the viewing surface 132 within a relatively short

window of time. The human eye will not detect the three separate colors, bur rather will

20   perceive a blending of the three light beams such that a consistent and desired hue appears at

that point on the viewing surface. Those skilled in the art will appreciate that this process may

be repeated numerous times along the path 140 to recreate a picture on the viewing surface

132.

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As discussed above, semiconductor laser diodes that emit in red and blue wavelengths are commercially available and can be used directly as the lasers 102, 104 to produce beams of red and blue laser light in the raster based system described above. A small form factor laser capable of producing a green beam of laser light has heretofore been generally unavailable.

5   Continuous-wave (CW) green laser light has been created by frequency-doubling an Nd:YAG or Nd:YVO4 infrared solid-state laser; however, the relaxation lifetime of such solid-state lasers may be too slow for some laser display applications. That is, these frequency doubled lasers may not be modulated sufficiently fa   high resolution display. The instant invention, however, demonstrate that it is possible to modulate an infrared semiconductor laser

10   diode to create displays of red, green or blue colors.

Figure 4 illustrates a block diagram of one embodiment of the laser 106 arranged to produce green laser light. Generally, an acousto-optic modulator (AOM) 400 may be configured to modulate a CW laser beam, such that green laser light may be produced.

The laser beam may be arranged to be generally incident at the Bragg angle to the

15   AOM 400. The interaction of the acoustic waves in the AOM, 400 generated by an RF frequency, and the laser beam creates diffraction orders. The diffracted laser beam is thus modulated. For example, when the AOM 400 is producing an acoustic signal and modulating the laser beam, the various diffraction orders are produced. However, when the AOM 400 is not modulating the laser beam (e.g., no acoustic signal is present), then the various diffraction

20   orders are not present (except for the 0th order). That is, the various diffraction orders may be turned "off and on," producing a modulated laser beam. Those skilled in the art will appreciate that while any of various diffracation orders may be utilized, the first order diffraction typically contains the most energy, and thus, is normally the ordered diffraction that is utilized by the system

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The Bragg relationship is captured by the following expression:

$$\theta_{Bragg} = \lambda f_c / 2 V_a$$

where θ_{Bragg} is the Bragg angle and is typically on the order of 1 degree, λ is the laser

wavelength, f_c is the RF frequency that generates the acoustic wave, and V_a is the speed of the

5   acoustic wave in the AOM medium.

To ensure high diffraction efficiency, the AOM may be generally aligned to an

accuracy of about $1/10^{th}$, of the Bragg angle or 0.1 degrees, or less. A mechanical alignment

system capable of this level of accuracy may   achieve and maintain in a consumer

display product. At a minimum, the mechanical alignment mechanism would add size and cost

10   to the product. Moreover, the quality of the alignment may vary over time or even with

changes in temperature and/or humidity. In any event, such a mechanical system would likely

prove to be rather delicate, limiting its application to laboratory type environments.

Instead of fine aligning the AOM 400 to the laser beam mechanically, it is possible to

tune the required Bragg angle to match the existing alignment of the laser/AOM assembly by

15   changing the RF frequency that generates the acoustic wave within the AOM 400. That is, by

fine tuning the RF frequency applied to the AOM 400, the operation of the AOM 400 may be

adjusted to compensate for any misalignment between the AOM 400 and the laser beam. The

Bragg angle changes linearly to the RF frequency, as is evident by the above expression.

Figure 4 shows one embodiment of an alignment set up using a photodiode 402 to

20   measure the power in the diffracted laser beam. The photodiode signal is coupled to an RF

frequency generator 404, which is preset to produce a generally desired RF frequency signal.

The photodiode signal operates to fine tune the RF frequency to compensate for any variations

in the Bragg angle. The RF frequency can be tuned by various well known structures, such as

capacitance or inductance tuning, or a voltage controlled oscillator. The photodiode 402 may

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be positioned to receive one or more of the ordered beams produced by the AOM 400. If the

photodiode 402 is positioned to capture the signal in the zeroth order beam (as shown), which

is a modulated version of the incident laser beam along its path of propagation, the control loop

is configured to stop fine tuning the RF frequency generator 404 when minimum power is

5   measured by the photodiode 402. If the photodiode is positioned to capture the 1st order

diffracted beam, which is usually the beam used for display, the control loop stops adjusting

the RF frequency generator 404 when maximum power is measured by the photodiode 402.

Thus, the electronic tuning of the   t best can reduce or eliminate fine

mechanical alignment. At the minimum, it provides an additional adjustment for the alignment

10   procedure.

Unless specifically stated otherwise, or as is apparent from the discussion, terms such

as "processing" or "computing" or "calculating" or "determining" or "displaying" or the like,

refer to the action and processes of a computer system, or similar electronic computing device,

that manipulates and transforms data represented as physical, electronic quantities within the

15   computer system's registers and memories into other data similarly represented as physical

quantities within the computer system's memories or registers or other such information

storage, transmission or display devices.

Those skilled in the art will appreciate that the various system layers, routines, or

modules illustrated in the various embodiments herein may be executable control units. The

20   control units may include a microprocessor, a microcontroller, a digital signal processor, a

processor card (including one or more microprocessors or controllers), or other control or

computing devices. The storage devices referred to in this discussion may include one or more

machine-readable storage media for storing data and instructions. The storage media may

include different forms of memory including semiconductor memory devices such as dynamic

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or static random access memories (DRAMs or SRAMs), erasable and programmable read-only memories (EPROMs), electrically erasable and programmable read-only memories (EEPROMs) and flash memories; magnetic disks such as fixed, floppy, removable disks; other magnetic media including tape; and optical media such as compact disks (CDs) or digital video

5   disks (DVDs). Instructions that make up the various software layers, routines, or modules in the various systems may be stored in respective storage devices. The instructions when executed by the control units cause the corresponding system to perform programmed acts.

The particular embodiments disclosᴇ   ustrative only, as the invention may be modified and practiced in different but equivalent manners apparent to those skilled in the

10   art having the benefit of the teachings herein. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. Consequently, processing circuitry required to implement and use the described system may be implemented in application specific integrated circuits, software-driven processing circuitry, firmware, programmable logic devices, hardware, discrete components or arrangements of the

15   above components as would be understood by one of ordinary skill in the art with the benefit of this disclosure. It is therefore evident that the particular embodiments disclosed above may be altered or modified and all such variations are considered within the scope and spirit of the invention. Accordingly, the protection sought herein is as set forth in the claims below.

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CLAIMS

WE CLAIM:

1.   A method for modulating laser light, comprising:

delivering laser light to an optic modulator at an angle generally incident at the Bragg

angle relative to the optic modulator; and

adjusting the operation of the optic modulator to compensate for at least a portion of a

deviation of the laser light from   ₂.

2.   A method, as set forth in claim 1, wherein the optic modulator is an acoustic optic

modulator adapted to produce an acoustic wave as a function of a radio frequency

signal, and wherein adjusting the operation of the optic modulator to compensate

for at least a portion of a deviation of the laser light from the Bragg angle further

comprises measuring a characteristic of laser light of at least one ordered diffraction

produced by the optic modulator, and adjusting the radio frequency signal as a

function of the measured characteristic.

3.   A method, as set forth in claim 2, wherein measuring a characteristic of laser light

of at least one ordered diffraction produced by the optic modulator, and adjusting

the radio frequency signal as a function of the measured characteristic further

comprises measuring intensity of laser light of at least one ordered diffraction

produced by the optic modulator, and adjusting the radio frequency signal as a

function of the measured intensity.

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4.   A method, as set forth in claim 3, wherein measuring intensity of laser light of at least one ordered diffraction produced by the optic modulator, and adjusting the radio frequency signal as a function of the measured intensity further comprises measuring intensity of laser light of at least the first ordered diffraction produced by

5   the optic modulator, and adjusting the radio frequency signal as a function of the measured intensity.

5.   A method, as set forth in claim   :asuring intensity of laser light of at least the first ordered diffraction produced by the optic modulator, and adjusting the

10   radio frequency signal as a function of the measured intensity further comprises measuring intensity of laser light of at least the first ordered diffraction produced by the optic modulator, and adjusting the radio frequency signal to substantially maximize the measured intensity.

15   6.   A method, as set forth in claim 3, wherein measuring intensity of laser light of at least one ordered diffraction produced by the optic modulator, and adjusting the radio frequency signal as a function of the measured intensity further comprises measuring intensity of laser light of at least the zeroth ordered diffraction produced by the optic modulator, and adjusting the radio frequency signal as a function of the

20   measured intensity.

7.   A method, as set forth in claim 6, wherein measuring intensity of laser light of at least the zeroth ordered diffraction produced by the optic modulator, and adjusting the radio frequency signal as a function of the measured intensity further comprises

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measuring intensity of laser light of at least the zeroth ordered diffraction produced by the optic modulator, and adjusting the radio frequency signal to substantially minimize the measured intensity.

5   8.   A method, as set forth in claim 1, wherein the optic modulator is adjustable to vary an intensity of at least one ordered diffraction produced thereby, and wherein adjusting the operation of the optic modulator to compensate for at least a portion of a deviation of the laser light fro_____gle further comprises measuring the intensity of laser light of at least one ordered diffraction produced by the optic

10   modulator, and adjusting the optic modulator to produce a desired intensity of laser light of at least one ordered diffraction.

       9.   A method, as set forth in claim 4, wherein adjusting the optic modulator to produce a desired intensity of laser light of at least one ordered diffraction further comprises

15   adjusting the optic modulator to substantially maximize the desired intensity of laser light of at least one ordered diffraction.

       10.   A method for modulating laser light, comprising:
              delivering laser light to an optic modulator at an angle generally incident at the Bragg

20   angle relative to the optic modulator; and
       adjusting the optic modulator to produce a desired characteristic of laser light of at least one ordered diffraction.

15

11.   A method, as set forth in claim 10, wherein the optic modulator is an acoustic optic

      modulator adapted to produce an acoustic wave as a function of a radio frequency

      signal, and wherein adjusting the optic modulator to produce a desired characteristic

      of laser light of at least one ordered diffraction further comprises measuring a

5   characteristic of laser light of at least one ordered diffraction produced by the optic

      modulator, and adjusting the radio frequency signal as a function of the measured

      characteristic.

12.   A method, as set forth in claim 11, wherein measuring a characteristic of laser light

10   of at least one ordered diffraction produced by the optic modulator, and adjusting

      the radio frequency signal as a function of the measured characteristic further

      comprises measuring intensity of laser light of at least one ordered diffraction

      produced by the optic modulator, and adjusting the radio frequency signal as a

      function of the measured intensity.

15

13.   A method, as set forth in claim 12, wherein measuring intensity of laser light of at

      least one ordered diffraction produced by the optic modulator, and adjusting the

      radio frequency signal as a function of the measured intensity further comprises

      measuring intensity of laser light of at least the first ordered diffraction produced by

20   the optic modulator, and adjusting the radio frequency signal as a function of the

      measured intensity.

14.   A method, as set forth in claim 13, wherein measuring intensity of laser light of at

      least the first ordered diffraction produced by the optic modulator, and adjusting the

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radio frequency signal as a function of the measured intensity further comprises

measuring intensity of laser light of at least the first ordered diffraction produced by

the optic modulator, and adjusting the radio frequency signal to substantially

maximize the measured intensity.

5

15.   A method, as set forth in claim 12, wherein measuring intensity of laser light of at

least one ordered diffraction produced by the optic modulator, and adjusting the

radio frequency signal as a fun   ieasured intensity further comprises

measuring intensity of laser light of at least the zeroth ordered diffraction produced

10   by the optic modulator, and adjusting the radio frequency signal as a function of the

measured intensity.

16.   A method, as set forth in claim 15, wherein measuring intensity of laser light of at

least the zeroth ordered diffraction produced by the optic modulator, and adjusting

15   the radio frequency signal as a function of the measured intensity further comprises

measuring intensity of laser light of at least the zeroth ordered diffraction produced

by the optic modulator, and adjusting the radio frequency signal to substantially

minimize the measured intensity.

20   17.   A method, as set forth in claim 13, wherein adjusting the optic modulator to

produce a desired intensity of laser light of at least one ordered diffraction further

comprises adjusting the optic modulator to substantially maximize the desired

intensity of laser light of at least one ordered diffraction.

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18.   An apparatus for modulating laser light, comprising:

   means for delivering laser light to an optic modulator at an angle generally incident at

   the Bragg angle relative to the optic modulator; and

   means for adjusting the operation of the optic modulator to compensate for at least a

5   portion of a deviation of the laser light from the Bragg angle.

19.   An apparatus for modulating laser light, comprising:

   a source of laser light;

   an optic modulator arranged to receive laser light at an angle generally incident at the

10   Bragg angle relative to the optic modulator; and

   means for adjusting the operation of the optic modulator to compensate for at least a

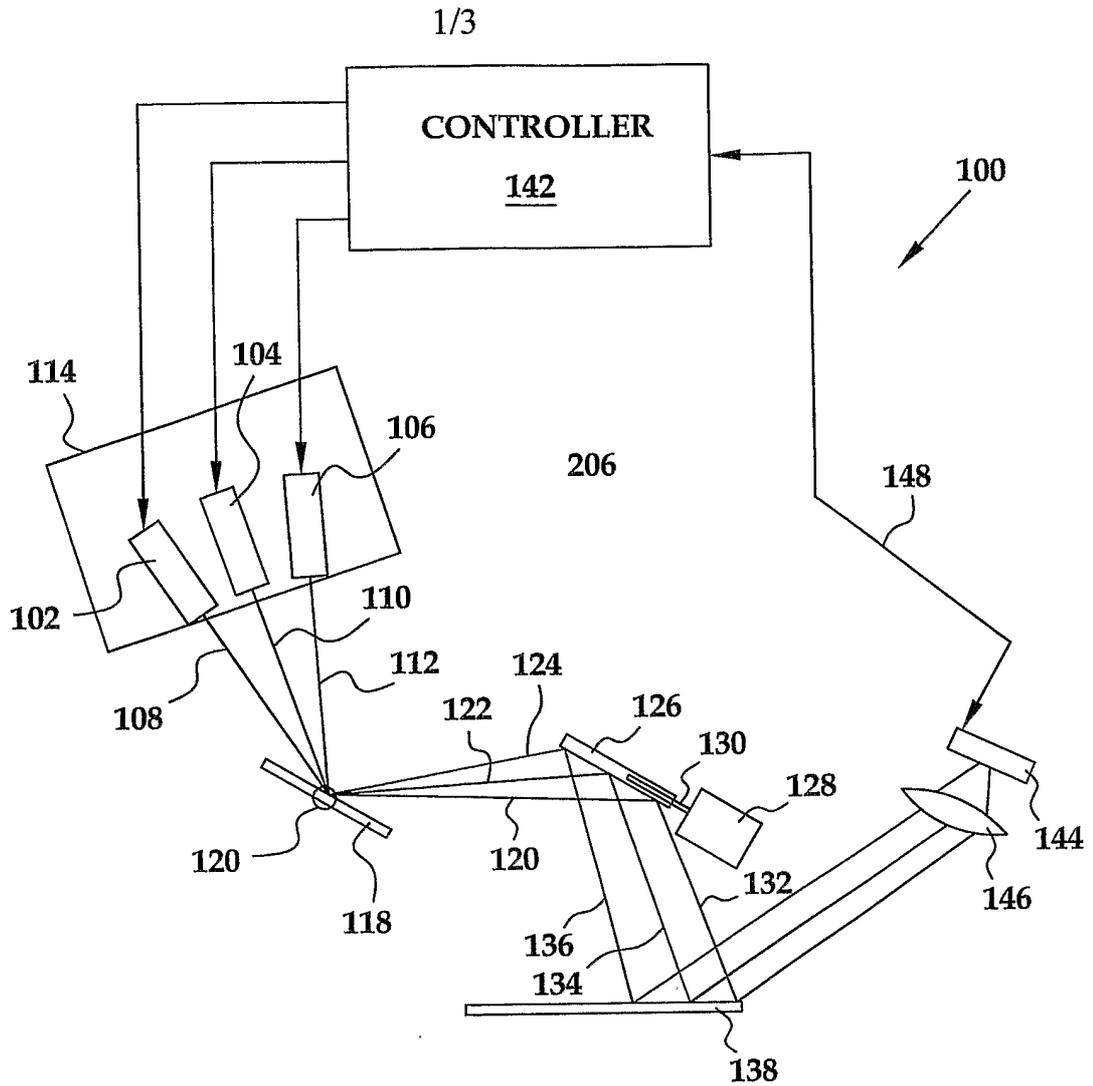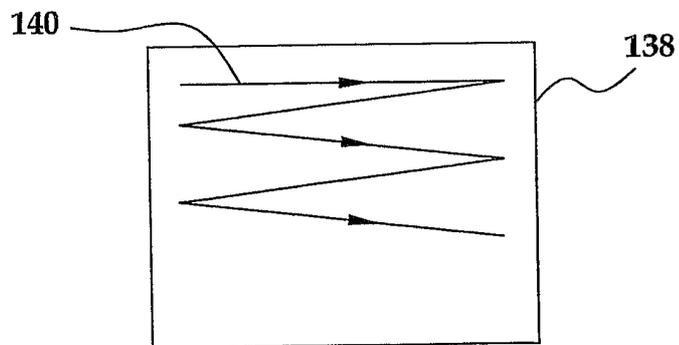   portion of a deviation of the laser light from the Bragg angle.

20.   An apparatus for modulating laser light, comprising:

15   a source of laser light;

   an optic modulator arranged to receive laser light at an angle generally incident at the

   Bragg angle relative to the optic modulator;

   a sensor adapted to measure a characteristic of laser light of at least one ordered

   diffraction produced by the optic modulator;

20   a controller adapted to adjust the operation of the optic modulator to compensate for at

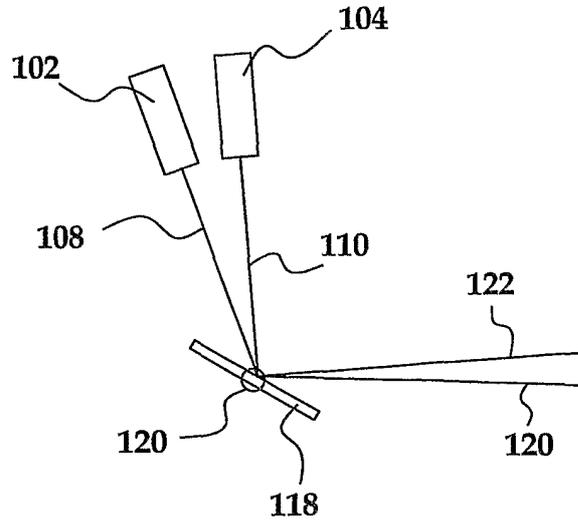   least a portion of a deviation of the laser light from the Bragg angle.
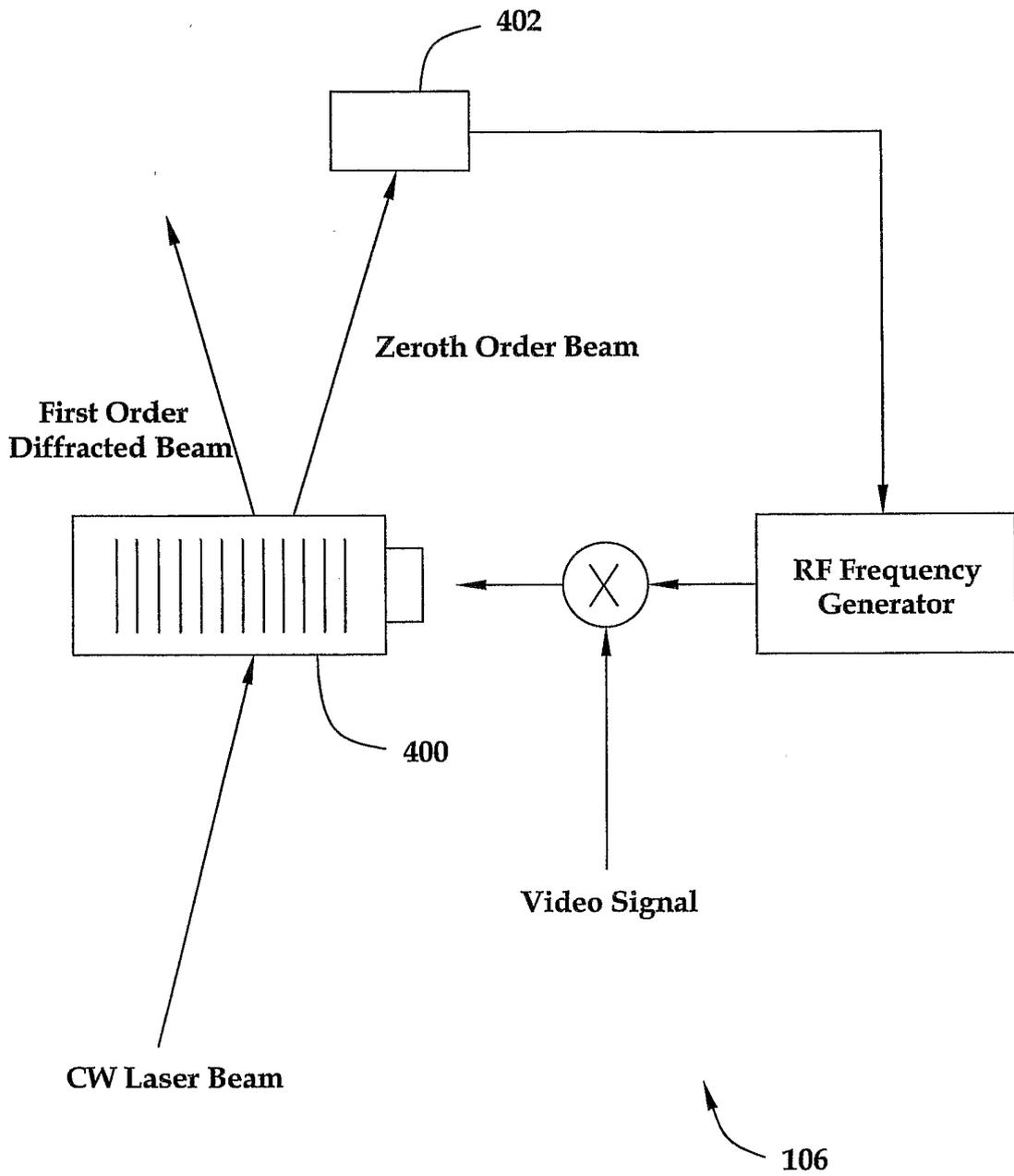
1/3

FIGURE 1

FIGURE 2

2/3

FIGURE 3A

FIGURE 3B

402

Zeroth Order Beam

First Order
Diffracted Beam

RF Frequency
Generator

⊗

400

Video Signal

CW Laser Beam

106
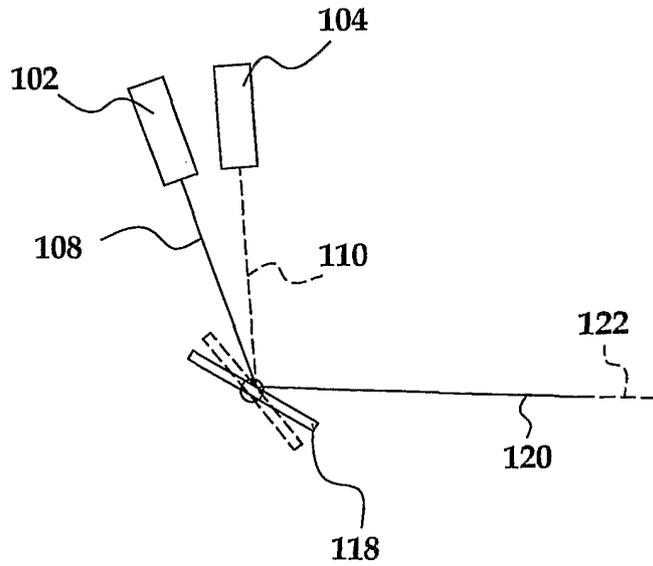
FIGURE 4

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7   G02F1/11   H04N9/31

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)

IPC 7   G02F   H04N

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 practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 938 554 A (WILSON ET AL) 3 July 1990 (1990-07-03)	1-3, 18-20
Y	the whole document	4-9
X	PATENT ABSTRACTS OF JAPAN vol. 014, no. 391 (E-0968), 23 August 1990 (1990-08-23) -& JP 02 143579 A (HITACHI ELECTRON ENG CO LTD), 1 June 1990 (1990-06-01)	10-14, 17-20
Y	abstract	4-9,15, 16
Y	PATENT ABSTRACTS OF JAPAN vol. 003, no. 052 (E-108), 7 May 1979 (1979-05-07) -& JP 54 031762 A (RICOH CO LTD), 8 March 1979 (1979-03-08) abstract	6,7,15, 16

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[X] Further documents are listed in the continuation of box C.	[X] Patent family members are listed in annex.

° Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 April 2005	25/04/2005

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Ammerlahn, D

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INTERNATIONAL SEARCH REPORT

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	PATENT ABSTRACTS OF JAPAN vol. 003, no. 107 (E-136), 8 September 1979 (1979-09-08) -& JP 54 085744 A (MITSUBISHI ELECTRIC CORP), 7 July 1979 (1979-07-07) abstract ————	6,7,15, 16

Form PCT/ISA/210 (continuation of second sheet) (January 2004)

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 4938554	A	03-07-1990	NONE		
JP 02143579	A	01-06-1990	NONE		
JP 54031762	A	08-03-1979	NONE		
JP 54085744	A	07-07-1979	JP JP	1387713 C 61024691 B	14-07-1987 12-06-1986