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(54) Dual-beam scanning electro-optical device from single-beam light source
Elektrooptische Vorrichtung mit zwei Abtaststrahlen aus einer Einstrahllichtquelle
Appareil électrooptique de balayage à deux rayons à partir d’une source de lumière à rayon unique

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Description

This invention relates to a raster output scanning system and more particularly, to a raster scanning system which utilizes a single light source, an electro-optical device and a beam-splitter to generate and modulate two light beams with two different trains of information, without using a modulator, in order to scan two adjacent scan lines simultaneously.

The present invention provides a raster output scanner comprising:

- a laser light source for emitting a light beam;
- polarizing means located in the path of the light beam from said laser light source for receiving the light beam and polarizing the light beam at a first polarization degree, a second polarization degree or a third polarization degree; a medium;
- a beam-splitter located in the path of the polarized light beam from said polarizing means for receiving the polarized light beam and splitting the polarized light beam into two light beams for simultaneously scanning two scan lines on said medium;
- scanning means located in the path of the two light beams from said beam-splitter and being so constructed and arranged to scan said two light beams onto said medium;
- said beam-splitter and said polarizing means being so constructed and arranged that a polarized light beam will pass through said beam-splitter to one of said scan lines on said medium when said polarization means is at said first polarization degree, a polarized light beam will be split into two portions with one portion passing through said beam-splitter to said one scan line on said medium and the other portion of said polarized light beam being deflected to the other of said scan lines on said medium when said polarization means is at said second polarization degree, and a polarized light beam will be deflected to said other scan line on said medium when said polarization means is at said third polarization degree;
- means for providing two different trains of pixel information one for each of said scan lines;
- controlling means being electrically connected to said polarizing means and responsive to said two trains of pixel information for setting said polarizing means at either said first polarization degree, said second polarization degree or said third polarization degree in accordance with the two trains of pixel information, whereby the two light beams are modulated to scan said two scan lines.

Other objects will become apparent from the following description with reference to the drawings wherein:

Figure 1 shows a raster scanner of this invention;
Figure 2 shows an electro-optical device utilized in this invention for rotating the polarization of the light beam passing through the electro-optical device;
Figure 3 shows a beam-splitter utilized in this invention to split the vertical and horizontal components of a polarized light beam;
Figure 4 shows Gaussian distributions of two light beams which partially overlap;
Figure 5 shows the power requirements of the laser light source for different pixels;
Figure 6 shows the polarization degree of the electro-optical device for each pixel;
Figure 7 shows a train of pixel information for the light beam generated from the horizontal component;
Figure 8 shows a train of pixel information for the light beam generated from the vertical component; and
Figure 9 shows a block diagram of a circuit which generates the proper inputs for the laser light source and the electro-optical device.

Referring to Figure 1, there is shown a raster scanner 10 of this invention. The raster scanner 10 contains a laser light source 12, a collimator 14, pre-polygon optics 16, an electro-optical device 18, a beam-splitter 20, rotating polygon mirror 22, post polygon optics 24 and a photosensitive medium 26. The laser light source 12 produces a light beam 28 and sends it to the electro-optical device 18 through the collimator 14 and the pre-polygon optics 16.

For slow applications (millisecond-type), the electro-optical device 18 can be a liquid crystal cell and for faster applications (sub-microsecond) it can be an electro-optical Kerr-type cell or a magnetooptic cell. Referring to Figure 2, upon applying a control voltage V or a control current 1, the electro-optical device 18 rotates the polarization of the light beam passing through the electro-optical device 18. For example, the arrow 30 shows the polarization of the light beam before it enters the electro-optical device 18 and the arrows 30p, 30q and 30r show the polarization of the light beam after it exits the electro-optical device 18 based on three different control voltages. Depending on the control voltage, the light beam 28 exiting the electro-optical device 18 will have only one polarization.

Referring to Figure 3, the light beam 28 from the electro-optical device 18 (Figure 2) is sent to the beam-splitter 20. The beam-splitter 20 can be any type of birefringent crystal such as calcite, TeO2, LiNbO3 or a similar crystal. If
the polarization $\theta_0$ of the light beam exiting the electro-optical device 18 (Figure 2) has an angle $\theta$ with the Y axis of the crystal; then the polarization can be imaged on two axes Y and X (X axis being perpendicular to Y axis). The polarized component $\theta_0_{xy}$ is along the Y axis of the crystal and the polarized component $\theta_0_{xz}$ is along the X axis of the crystal. In the above crystals, a polarized component along the X axis of the crystal will pass through the crystal without any change. However, the Y component will be deflected in an angle inside the crystal and while exiting the crystal it will be deflected in such a manner that it exits parallel to the first component.

Referring back to Figure 1, the two beams 32 and 34 will be sent to the rotating polygon mirror 22. The rotating polygon has a plurality of facets 36, each of which is a plane mirror. The facets 36 of the rotating polygon mirror 22 reflect the light beams 32 and 34 and also cause the reflected light beams 32 and 34 to revolve about an axis near the center of the reflection of the rotating polygon mirror 22 scanning two lines. These reflected light beams 32 and 34 can be utilized to scan a document at the input end of an imaging system as a raster input scanner or can be used to impinge upon a photographic film or a photosensitive medium 22, such as a xerographic drum at the output of the imaging system.

Referring to Figure 4, there are shown the Gaussian distributions 36 and 38 of the two light beams 32 and 34. By adjusting the electro-optical device 18 (Figure 1) to polarize the light beam at $45^\circ$, the two light beams exiting the beam-splitter 20 (Figure 1) will have the same intensity. Also, depending on the thickness of the crystal used as the beam-splitter 20, the distance 42 between the peak 44 of the Gaussian distribution 36 and the peak 46 of the Gaussian distribution 38 can be changed. By selecting a proper crystal, the distance 42 between the two peaks can be kept equal to FWHM of a single light beam. Full width half max (hereinafter referred to as "FWHM") is the width of the Gaussian distribution at half of the maximum intensity.

By having two light beams with a distance between the two peaks equal to FWHM, two adjacent scan lines can be scanned. This enables dual-beam scanning with cross-polarized beams on adjacent scan lines. Double-beam scanning doubles the throughput of the polygon or it can be used to slow down the polygon rotation by half compared to a single spot scanning. The disclosed embodiment of this invention provides a technique to scan two adjacent scan lines by utilizing a single laser light source. While scanning two scan lines, each light beam requires a different train of pixel information. Also, the disclosed embodiment of this invention is capable of modulating the two light beams by utilizing a single laser light source 14, the electro-optical device 18 and the beam-splitter 20.

However, for each pixel, depending on the combination of the pixels from each train of pixel information, the laser light source 12 has to provide a different power and the electro-optical device 18 has to provide a different polarization.

Since the light beam from the laser light source is being split into two beams, the intensity of the light beam from the laser light source has to be divided between the two light beams. The ratio between the two intensities depends on the amount of polarization. However, for scanning two adjacent light beams, the intensities of the two light beams should be kept the same.

In order to keep a fixed intensity for both light beams with any pixel combination, the power of the laser light source has to be adjusted based on the pixel combination for the two light beams. For example, if both light beams are On, the power of the laser light source has to be at its maximum (100%). In this case, each light beam receives half the intensity (50%) from the laser light source. However, depending on the pixel information, if one of the light beams is Off, then the power of the laser light source has to be decreased to 50%. The reason for decreasing the power is that if the power is kept at its maximum (100%), since only one light beam is On, that one light beam will receive the entire intensity (100%) from the laser light source which is double the intensity of each light beam when both light beams are On. On the other hand, if the power of the laser light source is decreased to 50%, the light beam which is On will receive all the intensity (50%) from the laser light source which is equal to the intensity of each light beam while both beams are On.

Therefore, there are three power levels for each light source: 100% for the time when both light beams are On, 50% for the time when one light beam is On and 0% (Off) for the time when both light beams are Off. By observing the combination of the pixels from each train of pixel information, the power of the laser light source can be adjusted for each pixel.

In the same fashion, the degree of polarization has to be changed for each pixel. Depending on pixels, if two light beams are required, the electro-optical device has to be set to polarize the light beam at $45^\circ$. However, if only one light beam is needed, the polarization will be set at either 0° (horizontal) or at 90° (vertical) depending on if the light beam 32 (Figure 3) or the light beam 34 (Figure 3) is needed respectively.

For example, referring to Figures 5, 6, 7 and 8, there are shown the power requirements of the laser light source for different pixels, the polarization degree for each pixel, train of pixel information for beam 32 and the train of pixel information for beam 34 respectively. In Figures 5, 6, 7 and 8, the horizontal axes represent time. In Figure 5, the vertical axis represents the output power of the laser light source, in Figure 6, the vertical axis represents the polarization factor and in Figures 7 and 8 the vertical axes represent amplitude of the pixel information.

Referring to Figures 5, 6, 7 and 8, as it can be observed, for pixel P1, the two light beams 32 and 34 are On. Therefore, for pixel P1, the power of the laser light source 12 (Figure 5) has to be at its maximum (100%) and the
electro-optical device 18 has to be set to polarize the beam at 45° (Figure 6). For pixel P2, the light beam 32 is Off and the light beam 34 is On. For this combination, the power of the laser light source 12 has to be at 50% (Figure 5) and the electro-optical device 18 has to be set to polarize the beam at 90° (Figure 6). For pixel P3, the light beam 32 is On and the light beam 34 is Off. For this combination, the laser light source 12 has to be at 50% (Figure 5) and the electro-optical device 18 has to be set to polarize the beam at 0° (Figure 6). For pixel P4, the light beams 32 and 34 are Off. For this combination, the laser light source 12 has to be at 0% (Figure 5) and the electro-optical device 18 can be set to polarize the beam at any polarization degree.

Table 1 summarizes the required output power of the laser light source and the required polarization degree of the electro-optical device based on different combinations of the pixels for the two light beams. Where both pixels from Video1 and Video2 are zero the laser light source should be turned Off and the polarization of electro-optical device does not make any difference. Where Video1 is 0 and the Video2 is 1, then the power of the laser light source should be at 50% and the polarization of electro-optical device should be at 0° (horizontal). Where Video1 is 1 and Video2 2 is 0, then the power of the laser light source should be at 50% and the polarization of electro-optical device should be at 90° (vertical). Finally, when both pixels Video1 and Video2 are 1, then the power of the laser light source should be at 100% and the polarization of electro-optical device should be at 45°.

<table>
<thead>
<tr>
<th>Pixel info for light beam 1 (Video1)</th>
<th>Pixel info for light beam 2 (Video2)</th>
<th>Laser Output Power</th>
<th>Electro-optical Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>any</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>50%</td>
<td>0°</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>50%</td>
<td>90° V</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>100%</td>
<td>45° V/2 Volts</td>
</tr>
</tbody>
</table>

Referring to Figure 9, there is shown a block diagram 50 of a circuit which generates the proper inputs to the laser light source 12 and the electro-optical device 18 in accordance with the combination of two trains of pixel information. Two trains of pixel information Video1 and Video2 are connected to adder 52 which is responsible to add the voltage of the two pixels. For simplicity, hereinafter, the train of pixel information Video1 will be referred to as “Video1” and the train of pixel information Video2 will be referred to as “Video2”. As a control voltage, the sum of the two voltages is sent to driver 53 of the laser light source 12.

A fixed voltage V and Video1 are connected to a multiplier 54. The multiplier 54, multiplies the voltage V by the value (0 or 1) of the pixel received from Video1 and sends the result to the divider 56. Divider 56 also receives Video2 as a control signal. The output of the divider 56 is connected to the electro-optical driver 58 to control the polarization factor of the electro-optical device 18.

In operation, according to Table 1 and referring to Figure 9, the voltages of the two pixels from Video1 and Video2 are added through the adder 52 and if both pixels are 0 then the sum of the voltages (the control voltage) will be 0 and therefore the laser light source will not emit any light beam. If both pixels from Video1 and Video2 are 1, then the sum of the voltages (the control voltage) will be double the voltage of a single pixel. In other words, the control voltage will be at its maximum which will cause the laser light source to emit a light beam with maximum intensity. However, if only one of the pixels from Video1 and Video2 is On, then the sum of the two voltages will be equal to the voltage of a single pixel and therefore the control voltage will be equal to half of the maximum voltage. This causes the laser light source to emit a light beam with half intensity.

Since the Multiplier 54 multiplies the voltage V by the value (0 or 1) of the pixel received from Video1, the output of the multiplier will be either 0 or V depending on the value of the pixel. When the pixel from Video1 is 0, then the output of the multiplier 54 will be 0 and when the pixel from Video1 is 1, then the output of the multiplier 54 will be V. Video2 is used as a control signal to set the divider 56 into mode 1 or mode 2. When the value of the pixel from Video2 is 0, the divider will be set into mode 1 in which it divides the voltage (V or 0) received from the multiplier 54 by 1 and when the value of the pixel from Video2 is 1, the divider will be set into mode 2 in which it divides the voltage (V or 0) received from the multiplier 54 by 2.

As a result, when Video1 is 0, divider 56 receives 0 instead of V and sends out a zero to the electro-optical driver 58. Therefore, the electro-optical device will polarize the light beam at 0° (horizontal). When Video1 is 1, then the divider 56 receives voltage V and depending on if Video2 is 0 or 1, the divider 56 will divide the voltage V by 1 or 2 respectively and sends out a voltage V or V/2 respectively. Therefore, when Video1 is 1 depending on if Video2 is 0 or 1, the electro-optical device will polarize the light beam at 90° or 45° respectively.
Claims

1. A raster output scanner comprising:

- a laser light source for emitting a light beam;
- polarizing means located in the path of the light beam from said laser light source for receiving the light beam and polarizing the light beam at a first polarization degree, a second polarization degree or a third polarization degree;
- a medium;
- a beam-splitter located in the path of the polarized light beam from said polarizing means for receiving the polarized light beam and splitting the polarized light beam into two light beams for simultaneously scanning two scan lines on said medium;
- scanning means located in the path of the two light beams from said beam-splitter and being so constructed and arranged to scan said two light beams onto said medium;
- said beam-splitter and said polarizing means being so constructed and arranged that a polarized light beam will pass through said beam-splitter to one of said scan lines on said medium when said polarization means is at said first polarization degree, a polarized light beam will be split into two portions with one portion passing through said beam-splitter to said one scan line on said medium and the other portion of said polarized light beam being deflected to the other of said scan lines on said medium when said polarization means is at said second polarization degree, and a polarized light beam will be deflected to said other scan line on said medium when said polarization means is at said third polarization degree;
- means for providing two different trains of pixel information one for each of said scan lines;
- controlling means being electrically connected to said polarizing means and responsive to said two trains of pixel information for setting said polarizing means at either said first polarization degree, said second polarization degree or said third polarization degree in accordance with the two trains of pixel information, whereby the two light beams are modulated to scan said two scan lines.

2. The raster output scanner recited in claim 1, further comprising:

- selecting means being electrically connected to said laser light source and responsive to said two trains of pixel information for setting said laser light source at maximum intensity, at half intensity or at zero intensity in accordance with the two trains of pixel information.

3. The raster output scanner recited in claim 1 or 2, wherein said light source is at maximum intensity when said polarizing means is at said second polarization degree, and said light source is at half intensity when said polarizing means is at either said first polarization degree or said third polarization degree.

4. The raster output scanner recited in claim 1, 2 or 3, wherein the first polarization degree is 0°, the second polarization degree is 45° and the third polarization degree is 90°.

Patentansprüche

1. Rasterausgabe-Abtasteinrichtung, die aufweist:

- eine Laserlichtquelle zum Emissieren eines Lichtstrahls;
- eine Polarisationseinrichtung, die in den Pfad des Lichtstrahls von der Laserlichtquelle zum Aufnehmen des Lichtstrahls und zum Polarisieren des Lichtstrahls unter einem ersten Polarisationsgrad, einem zweiten Polarisationsgrad oder einem dritten Polarisationsgrad angeordnet ist;
- ein Medium;
- einen Strahlteiler, der in dem Pfad des polarisierten Lichtstrahls von der Polarisationseinrichtung zum Aufnehmen des polarisierten Lichtstrahls und zum Aufteilen des polarisierten Lichtstrahls in zwei Lichtstrahlen für ein simultanes Abtasten von zwei Abtastlinien auf dem Medium angeordnet ist;
- eine Abtasteinrichtung, die in dem Pfad der zwei Lichtstrahlen von dem Strahlteiler angeordnet ist, und so
aufgebaut und angeordnet ist, um die zwei Lichtstrahlen auf dem Medium abzutasten;

wobei der Strahlteiler und die Polarisiereinrichtung so aufgebaut und angeordnet sind, daß ein polarisierter Lichtstrahl durch den Strahlteiler zu einer der Abastlinien auf dem Medium hindurchfährt, wenn sich die Polarisationseinstellung unter dem ersten Polarisationsgrad befindet, wobei sich ein polarisierter Lichtstrahl in zwei Bereiche mit einem Bereich, der durch den Strahlteiler zu der einen Abastlinie auf dem Medium hindurchführte, und dem anderen Bereich des polarisierten Lichtstrahls, der zu der anderen der Abastlinien auf dem Medium abgelenkt wird, wenn sich die Polarisationseinstellung unter dem zweiten Polarisationsgrad befindet, aufteilen wird, und ein polarisierter Lichtstrahl zu der anderen Abastlinie auf dem Medium abgelenkt werden wird, wenn sich die Polarisationseinstellung unter dem dritten Polarisationsgrad befindet;

eine Einrichtung zum Liefern von zwei unterschiedlichen Zügen aus Pixel-Informationen, einen für jede der Abastlinien;

eine Steuereinrichtung, die elektrisch mit der Polarisationseinstellung verbunden ist und auf die zwei Züge von Pixel-Informationen zum Einstellen der Polarisationseinstellung unter entweder dem ersten Polarisationsgrad, dem zweiten Polarisationsgrad oder dem dritten Polarisationsgrad entsprechend den zwei Zügen aus Pixel-Informationen anspricht, wodurch die zwei Lichtstrahlen so moduliert werden, um die zwei Abastlinien abzutasten.

2. Rasterausgabe-Abtasteinrichtung nach Anspruch 1, die weiterhin aufweist:

eine Auswahleinrichtung, die elektrisch mit der Laserlichtquelle verbunden ist und auf die zwei Züge aus Pixel-Informationen zum Einstellen der Laserlichtquelle bei einer maximalen Intensität, bei einer halben Intensität oder bei einer Null-Intensität entsprechend den zwei Zügen aus Pixel-Informationen ansprechend ist.

3. Rasterausgabe-Abtasteinrichtung nach Anspruch 1 oder 2, wobei sich die Lichtquelle bei einer maximalen Intensität dann befindet, wenn sich die Polarisationseinstellung bei dem zweiten Polarisationsgrad befindet, und die Lichtquelle bei der halben Intensität befindet, wenn sich die Polarisationseinstellung bei entweder dem ersten Polarisationsgrad oder dem dritten Polarisationsgrad befindet.

4. Rasterausgabe-Abtasteinrichtung nach Anspruch 1, 2 oder 3, wobei der erste Polarisationsgrad 0° ist, der zweite Polarisationsgrad 45° ist und der dritte Polarisationsgrad 90° ist.

Revendications

1. Dispositif de balayage de sortie de trame comprenant :

   une source de lumière laser pour émettre un faisceau lumineux ;
   un moyen de polarisation situé sur le trajet du faisceau lumineux en provenance de ladite source de lumière laser pour recevoir le faisceau lumineux et polariser les faisceaux lumineux à un premier degré de polarisation,
   un second degré de polarisation ou à un troisième degré de polarisation ;
   un support ;
   un séparateur de faisceaux situé sur le trajet du faisceau lumineux polarisé en provenance dudit moyen de polarisation pour recevoir le faisceau lumineux polarisé et séparer le faisceau lumineux polarisé en deux faisceaux lumineux pour animer d'un mouvement de balayage simultané deux lignes de balayage sur ledit support ;
   un moyen de balayage situé sur le trajet des deux faisceaux lumineux à partir dudit séparateur de faisceaux et étant conçu et agencé de manière à animer d'un mouvement de balayage lesdits deux faisceaux lumineux sur ledit support ;
   ledit séparateur de faisceaux et ledit moyen de polarisation étant construits et agencés de telle manière qu'un faisceau lumineux polarisé passera à travers ledit séparateur de faisceaux comme l'une desdites lignes de balayage sur ledit support lorsque ledit moyen de polarisation se trouve audit premier degré de polarisation, un faisceau lumineux polarisé sera divisé en deux parties, une première partie passant à travers ledit séparateur de faisceaux comme ladite première ligne de balayage sur ledit support et l'autre partie dudit faisceau lumineux polarisé étant déviée comme l'autre desdites lignes de balayage sur ledit support lorsque ledit moyen de polarisation se trouve audit second degré de polarisation et un faisceau lumineux polarisé sera dévié com-
2. Dispositif de balayage de sortie de trame selon la revendication 1, comprenant en outre :

un moyen de sélection qui est relié électriquement à ladite source de lumière laser et sensible auxdits deux trains d'informations de pixels pour établir ladite source de lumière laser à son intensité maximale, à une demi-intensité ou à une intensité nulle en se conformant aux deux trains d'informations de pixels.

3. Dispositif de balayage de sortie de trame selon la revendication 1 ou 2, dans lequel ladite source de lumière se trouve à une intensité maximale lorsque ledit moyen de polarisation se trouve audit second degré de polarisation et ladite source lumineuse se trouve à une demi-intensité lorsque ledit moyen de polarisation se trouve soit audit premier degré de polarisation, soit audit troisième degré de polarisation.

4. Dispositif de balayage de sortie de trame selon la revendication 1, 2 ou 3, dans lequel le premier degré de polarisation est 0°, le second degré de polarisation est 45° et le troisième degré de polarisation est 90°.
FIG. 5

FIG. 6

FIG. 7

FIG. 8
FIG. 9