LASER Optical Beam Scanning Device

Cross-reference to related applications
This application claims the benefit of provisional Patent Application No. 804/DEL/2010 filled, 31 March 2010 with Indian patent office.

[Technical Field]

The present invention relates to an image formation device and laser video projector a color image formation method, a video or image projector, by means of scanning a image or video information modulated LASER optical beam on white surface.

Secondary technical field related to this invention is Scanning Assembly(Laser Scanning Unit) used in various devices like laser jet printers, photo copy machines and various devices used LASER beam scanning to record image on optical sensitive drum to transfer it to recording medium(paper)

[Background Art]

In various prior arts there were rotating mirror or a galvanometer type devices used to scan optical beam on screen likewise United States Patent numbers US 6426781, Jin-ho Lee and US 007355657 Chilla et al., US 6,020,937 Bardmesser. in these invention method for Laser beam scanning is electromechanical, and using a rotating mirror for horizontal scanning of Laser beam and a slow speed rotating, or galvanometer type mirror for vertical scanning of the laser beam.
There are few other examples of image and video projection by other technologies like digital micro-mirror device (DMD) specially used in DLP projectors.

Column-Scanned Architecture of E&S Laser Projector wherein image is produce by MEMS The Grating Light Valve Modulator (GLV)
GLV modulates a single pixel. But, in fact, the GLV is a linear array of many of these multi-ribbon elements, such that an entire column of pixels can be modulated at once. By illuminating the GLV with a column of light and then sweeping the modulated result across the screen, a dynamic projection display is achieved.

Sweeping of the light column across the screen is achieved by galvanometer type scanning mirror.

[Technical Problem]

With prior arts where polygonal rotating mirror or galvanometer type mirror are used for optical beam scanning on the screen main problem is to synchronizing the retrace period of scanning beam, as with PAL and NTSC video scanning, trace period used to be long then retrace period while rotating mirror provides equal trace and retrace periods results in keeping mirror at very high speed
also, there are chances of distortion of video image on both the sides of the screen in galvanometer type scanner mirror due to the moment of inertia.

with polygonal rotating mirror as it is using multi facets, deflection angle, specially in horizontal direction, of deflected optical laser beam was narrow and limited so it was necessary to implement optical lances to project light on the screen resulting speckle noise and distortion in image quality.

high prerecession in rotating mirror devices is desired in micro meter range any kind of wobbling between rotor and stator will affect the polygonal mirror's reflection angle and thus deflected beam will overlaps to its subsequent scanned lines, hence a highly precision manufacturing production line is needed to produce such devices
other factor is friction, bear and tear as being rotating parts at very high speed hence life and precision of the device is relatively short.

A additional circuitry, microcontrollers was need to calculate speed of rotating mirror according to image refresh rate and resolution, for instance at 60 Hz refresh rate and 120 Hz refresh rate the rotation speed of mirror will be different.

With dielectric micro-mirror array. (DMD) technique used with DLP projectors, resolution of the video or image are pre-defined and not changeable also luminous flux is not utilized 100% , result less contrast , brightness and color reproduction is not close to spectral sensitivity of eye.

For conventional video projectors, a projection display displaying video images on a screen has been widely spread. For a projection display, a lamp light source is generally employed. However, a lamp light source has drawbacks in that the lifetime is short, the light utilization efficiency is low, and the color reproduction range is limited.

[Technical Solution and Advantageous effect]

Proposed optical image formation device which is supporting all video format, aspect-ratio and capable to reproduce video and image of any resolution not only restricted to pre-defined resolution, reason being it is using continuous scanning approach, thus providing dynamic resolution,

Also frequency , magnitude and length of displacement of piezoelectric actuator is proportional to applied signal waveform and frequency so no need to implement additional circuitry for rotation calculation.

Proposed device in this invention is robust and easy for mass production due to simplicity of mechanism with comparison to previous arts in this field like optical beam scanning assembly or scanning devices comprising the rotating mirrors were need to maintain highly precision and being a rotating part the corrosion and the life of a device was a concern, also the arrangement and assembly of those mirrors were not easy ,
moreover this LCD, MEMS, and DMD projectors have complicated and micro level technology and special manufacturing unit required to make DMD, MEMS and LCD still they have restricted resolution, contrast ratio, response time and natural color reproduction.

this inventive step have overcome all the above problems by applying a method which is having no mechanical rotating parts which have to bear friction and needed a high precision production assembly line for production.
Also a wide deflection angle of incident beam has been achieved using spherical shape and cylindrical shaped mirrors by applying very minute displacement through piezo-electric actuators.
This invention in comparison to prior art where lots of restriction for projection angel and resolution were faced during image recreation solved.
present invention is easy in high volume production and cheap production cost.

[Description of Drawings]

'A' – stack of plats made of piezoelectric material responsible to vibrate or displacement of spherical shaped mirror along its axis in horizontal direction according applied signal's voltage and waveform.

'B'- stack of plats made of piezoelectric material responsible to vibrate or displacement of spherical shaped mirror along its axis in vertical direction according applied signal's voltage and waveform.

'C'- Horizontal and vertical synchronizing signal amplifier, separator and high voltage generator, to apply across the piezo actuators A and B.

'D'-LASER beam generator, and video/image signal modulator it modulate red green and blue LASER beams as per image information and combining optics composite them into a single laser beam L.

'E'- Rigid non vibrating base to accommodate scanning assembly

‘F’- Rigid non vibrating insulated metal arm to connect actuator A with B and provide base for actuator A.

‘F1’- Rigid non vibrating metal arm to connect and provide base for actuator ‘B’ further connecting

‘G’- all triangular shaped are metal plates which is inducing alternate high voltage static electrical field. It is connected to ‘C’ through the wire conductors.

‘L’- composite RGB laser beam modulated with image or video information.

‘S’- Screen on which laser beam ‘L’ will be project and scan it.

‘R’- very light weight highly reflective spherical shaped mirror.

‘Rh’- very light weight, highly reflective cylindrical shaped mirror for deflecting laser beam in horizontal plan.

‘Rv’- very light weight, highly reflective cylindrical shaped mirror for deflecting laser beam in vertical plan.

‘34’- f.theta. lens

Figure 1 is prior art and shows image or video signal modulation on red, green and blue laser optical beam it also shows combining optics to combine 3 laser beam to form one white laser beam.

Figure 2 is phenomenon description behind this invention that illustrate change in reflection angle of incident laser beam L with respect to deflection or displacement in position of spherical shaped mirror R.

Figure 3 is optical laser beam scanning device in accordance with proffered embodiment
where two dimensional optical beam scanning is achieved with spherical shaped mirror keeping piezo actuator A over/on the piezo actuator B.

figure 4 is optical laser beam scanning device where 2 D or only 1 dimensional scanning of optical beam is achieved with cylindrical shaped mirrors Rh and Rv.

[Detailed description of the invention, and best mode to perform with reference to preferred embodiment]

Referring figures 1, in which 3 Laser sources preferably laser diode respectively for Red Green and Blue primary colors
all 3 Laser beams are provided with focusing and conversance lances
and incident on arrangement of dichroic mirror or prism 67b, 68b as displayed in figure after passing through light modulator(AOM) these light modulator modulates each Laser beam according to video signal, or image information respectively for each R G B color
method for video signal or image information modulation on R G B laser beam and combining them into one composite optical beam with the help of combining optics, all that are prior art and for lustration purpose only.

going into further details of video signal modulation method and combining 3 R G B laser beam into one by means of dichroic mirror and description of figure 1 is not an objective of this invention

In the future description, above description will be considered to be embedded within laser source and video and image signal modulator and optical combining unit 'D'

Following specification describe the best method to perform this invention;

Present invention is based on the phenomenon when electrical voltage applied across a piezoelectric material it actuates and changes its dimensions and achieve significant displacement in length across its axis.
Increase in the length of piezoelectric actuator is depending upon frequency and signal waveform applied in the form of high voltage.

A Laser optical beam scanning device according to the present invention will be described in detail with reference to the attached drawings.
And, will consider laser beam L as video signal or image information modulated white laser light beam combination of all 3 color RGB laser beams into single beam the main wavelengths of the white light laser beam emitted from the light source D are respectively 488 nm, 514 nm, and 647 nm.

In operation mode laser beam L is incident on spherical shaped mirror 'R', mirror 'R' is mounted or secured by strong adhesive to the surface of piezoelectric actuator 'A' resulting to provide mirror 'R' motions and vibration in horizontal dimension or plane, according to synchronizing signal in the form of high voltage applied across the actuator 'A'.

Further this stack of piezoelectric actuator 'A' which is providing horizontal vibration to sphere mirror 'R' is connected to a support arm 'F', support arm F is further secured by strong adhesive or mounted on the top of the piezo actuator 'B', in the

manner as shown in Fig. 3, so that the Piezoelectric actuator ‘A’, thus, spherical shaped mirror ‘R’, can get motion or vibration in vertical plan too, along with vibrating in horizontal plan.
this whole assembly or more specifically piezoelectric actuator ‘B’ is fixed or secured by adhesive on the rigid platform ‘E’ which is ultimately providing base to actuator ‘B’ and to whole scanning assembly.

Also, a f.theta. lens 34 is installed at the leading end on the side of the screen ‘S’ of the spherical shaped mirror ‘R’. The f.theta. lens 34 corrects the shape and the size of the beam focused on the screen to be identical in the entire area of the screen. Also, the f.theta. lens controls the divergence angle of the beam scanned to the screen, thus controlling the size of the beam required on the screen. Namely, the f.theta. lens controls the picture of the screen to always be natural even when the screen S or scanning surface moves back and forth.

In the operation mode high voltage H, V synchronizing signal applied across both of the piezo actuators A and B from horizontal and vertical deflection sync signal amplifier of image processing unit ‘C’ respectively.

hence, piezo actuator ‘A’ provides spherical shaped mirror ‘R’ a motion in horizontal plan and it vibrates in left to right direction, piezo actuator ‘B’ provides spherical shaped mirror R a motion in vertical direction and it vibrates in up and down direction.

Thus a spherical shaped reflection mirror ‘R’ get the bi directional vibration in X Y (horizontal and vertical) plane according to horizontal and vertical synchronizing signal hence reflect and scan incident optical beam L on entire projector screen ‘S’ or any surface desired to be scan to form a image.

Figure 4 describes additional configuration available where scanning is needed only in one dimension (either in vertical plane or in horizontal plane) for instance, it can be used for Column-Scanned Architecture of E&S Laser Projector, wherein image is produced by Sweeping of the modulated light column across the screen is achieved by a galvanometer type scanning mirror.
Other examples are Barcode scanners and Laser Scanning Assembly Device for laser jet printers, these devices are made of galvanometer type reflection mirror or polygonal rotating mirror to scan optical laser beam on any surface.

Referred to the embodiment (figure 4) two separate reflecting cylindrical shaped mirrors will be used to form a deflating laser beam in X Y plan , there are two cylindrical shaped mirror ‘Rv’, and ‘Rh’ instead of a sphere mirror ‘R’ will be used facing to each other.

cylindrical shaped reflection mirror ‘Rh’ is mounted or secured by adhesive on the piezoelectric actuator ‘A’, and this piezoelectric actuator ‘A’ is fixed on a rigid support arm ‘F’ which is further fixed on solid rigid platform ‘E’ providing non vibrating structure to hold actuator ‘A’.

cylindrical shaped mirror ‘Rv’ is mounted on piezoelectric actuator B and positioned in front of cylindrical shaped mirror ‘Rh’ as shown in the figure 4

actuator B is fixed on a rigid support arm ‘F1’ , support arm ‘F1’ is further fixed on solid rigid platform E providing non vibrating structure to hold actuator ‘B’.

Also, a f.theta. lens 34 is installed at the leading end on the side of the screen S or surface to be scanned of the cylindrical shaped mirror ‘Rv’. The f.theta. lens 34 corrects the shape and the size of the beam focused on the screen to be identical in the entire area of the screen. Also, the f.theta. lens controls the divergence angle of the beam scanned to the screen, thus controlling the size of the beam required on the screen. Namely, the f.theta. lens controls the picture of the screen to always be natural even when the screen S or scanning surface moves back and forth.

In operating mode high voltage synchronizing signal from synchronization signal separator ‘C’ is applied across the actuators ‘A’ and ‘B’ , a vertical deflection sync pulse in the form of high voltage is applied across the piezoelectric actuator ‘B’ which generates deflection / vibration at cylindrical shaped mirror ‘Rv’ in vertical, up and down direction and a horizontal deflection sync signal in the form of high voltage is applied across the actuator ‘A’ it generates deflection /vibration at cylindrical shaped mirror ‘Rh’ in left to right, horizontal direction.

Incidence laser beam ‘L’ first change its path after deflecting in horizontal plan and incident on vertically vibrating cylindrical mirror ‘Rv’ it results scanning beam ‘L’ deflect in vertical plan also

when scanning is required in vertical direction (Y plane), a signal voltage is applied across the piezo actuator ‘B’ only and no voltage applied across actuator ‘A’

when scanning is required in horizontal direction (X plane), a signal voltage is applied across the piezo actuator ‘A’ only and no voltage applied across actuator ‘B’

by activating actuator ‘A’ or ‘B’, optical laser beam ‘L’ can be scanned on the screen ‘S’ or any surface in either direction depending upon the requirement of the system

hence remove any need of galvanometer type mirror or polygonal mirror to scan optical beam in vertical direction or in horizontal direction.

In other scenario ,for laser video projection mode, applying vertical sync signal across piezo actuator 'B' and horizontal sync signal across piezo actuator 'A' simultaneously, a dynamic projection display is achieved on screen 'S', and device will work as a laser video projector it can be used for out door advertisements or a laser television of a large screen since it is possible to realize a large screen having high brightness and high resolution which is difficult to realize by the conventional video projector.

[Industrial Applicability]

Present invention can be used for laser television of a large screen, laser video projector , out door advertisements, optical beam scanning on various peripheral like printers, barcode reader, computer-human interface devices, biometric finger print reader and sweeping of light column on the screen for MEMS and GLV generated image and video.