

DESCRIPTION

TRANSMISSION TYPE LIQUID CRYSTAL MASK MARKER

Field of the Invention

The present invention relates to a transmission type liquid crystal mask marker, and particularly to a transmission type liquid crystal mask marker suitable for printing on a workpiece which is required to have high accuracy.

Background Art

A transmission type liquid crystal mask marker is adapted for printing various static images on a surface of a workpiece by applying a high-density energy beam such as a laser beam to a transmission type liquid crystal mask (referred to as "a liquid crystal mask" hereinafter unless it is emphasized) on which the various static images are displayed, so as to apply the beam which is passed through a static image to the workpiece surface. In general, only static images for a mark are displayed on the liquid crystal mask of such a transmission type liquid crystal mask marker.

The inventor of the present invention has previously

made a proposal for maintaining the printing performance of a transmission type liquid crystal mask marker (refer to Japanese Patent Application No. 5-131167). This unpublished proposal (referred to as "first proposal" hereinafter) has been made in consideration of the facts that the light transmittance of a transmission type liquid crystal mask increases as the temperature increases and deterioration proceeds, thereby decreasing printing accuracy, and that the light transmittance of a transmission type liquid crystal mask can be controlled by regulating a driving voltage. In this proposal, a light emitting element and a light receiving element are added to a conventional transmission type liquid crystal mask marker (if required, a liquid crystal mask temperature sensor is also added, and the following program is also provided on a controller. Namely, light is applied to a static image on the liquid crystal mask from the light emitting element, and the transmitted light is received by the light receiving element so that an actual light transmittance Q is computed from the intensity of emitted light $R1$ and the intensity of received light $R2$. The applied voltage for a static image is regulated so that the actual light transmittance Q is equal to an optimum light transmittance Q_0 at the operation temperature. It is thus possible to maintain the printing performance of

various conventional transmission type liquid crystal mask markers.

However, the first proposal also has a new problem with respect to matching with a transmission type liquid crystal mask marker which has recently appeared and which has the performance of high-accuracy and high-speed continuous printing.

The applicant of the present invention has also proposed a transmission type liquid crystal mask marker comprising a YAG laser mask marker (refer to Japanese Patent Laid-Open No. 5-42379). This proposal (referred to as "second proposal" hereinafter) comprises a first XY deflecting device and a second XY deflecting device, which are provided in front of and behind a liquid crystal mask, respectively. A controller previously stores each of the divided images of the whole image which is divided, and successively displays the divided static images on the liquid crystal mask. A laser beam scans the divided static images by the first XY deflecting device, and the laser beam passed through each of the divided static images is deflected by the second XY deflecting device and applied to the workpiece surface to complete entire printing. As a result, high-accuracy and high-speed continuous printing is achieved.

However, a transmission type liquid crystal mask

marker such as the second proposal, which enables high-accuracy and high-speed continuous printing, has difficulties in timing (time matching) with the first proposal. Namely, it is necessary to investigate a new problem with respect to timing.

On the other hand, a transmission type liquid crystal mask marker, e.g., a YAG laser mask marker, is sometime provided with one of various sensors serving as a light receiving element. A silicon photodiode is frequently used as a light receiving unit of the liquid receiving element in consideration of the cost, quality, temperature characteristics and compatibility with a light emitting element. As shown in Fig. 6, sensitivity A of the silicon photodiode within the wavelength region ($1.06\text{ }\mu\text{m}$) of a YAG laser is lower than the sensitivity within a shorter wavelength region (for example, refer to A. Yariv: Basis of Photoelectronics, P. 400, Maruzen (1988)). For example, when a semiconductor laser (wavelength of about 800 nm) or a He-Ne laser (wavelength of 633 nm), which has high energy density, is used as the light emitting element, the sensitivity of the YAG laser is as low as about 1/10 of the sensitivity of such a laser. When a short-wavelength laser is used as the light emitting element, therefore, even if the YAG laser beam is scattered, effects on the light receiving unit can

relatively be decreased, thereby preventing the problem with respect to a S/N ratio (signal/noise ratio).

However, in a transmission type liquid crystal mask marker comprising a YAG laser using Q switch or a pulse oscillation YAG laser, a laser pulse has high peak power. Although this peak power depends upon the operation conditions of the YAG laser or the structure of the YAG laser mask maker, the peak power is generally not less than 1 kW. The intensity of the scattered YAG laser beam which is applied to the light receiving unit is increased depending upon the arrangement of the light receiving unit of the light receiving element. As a result, noise occurs in sensor output (output of the light receiving element) due to the YAG laser beam, and the S/N ratio of the detection system of the light receiving element is thus decreased, thereby making unstable the operation of the YAG laser mask marker and deteriorating printing accuracy. In an extreme case, there are the problems that a sensing operation is made impossible, and that an error occurs in the operation of the YAG laser mask marker.

Disclosure of the Invention

The present invention has been achieved for solving the above problems of prior art, and an object of the

present invention is to provide a transmission type liquid crystal mask marker which enables incorporation of a program for maintaining printing accuracy into a conventional transmission type liquid crystal mask marker, and which enables stable printing with high precision.

A transmission type liquid crystal mask marker according to the present invention comprises light emitting means and light receiving means which are connected to a controller, and a transmission type liquid crystal mask to which a voltage is applied from the controller to successively rewrite and display various static images for a mark and appropriately display a static image to be tested, wherein the light emitting means is light emitting means for applying light to the displayed static image to be tested, the light receiving means is light receiving means for receiving the light passed through the static image to be tested, and the controller is a controller for previously storing an optimum light transmittance, during rewriting of at least one of the static images for a mark, performing at least once the displaying of the static image to be tested and then the attaining of an equipotential state of all common terminals and segment terminals of the transmission type liquid crystal mask, in this order, and then performing at least once the displaying of a static image for a mark and

the attaining of an equipotential state up to the termination of the rewriting time so as to finally attain an equipotential state, in this order, inputting the intensity of received light from the light receiving element during the displaying of the static image to be tested, computing the actual light transmittance of the transmission type liquid crystal mask from the intensity of received light and the intensity of emitted light, and regulating a voltage for a static image applied to the transmission type liquid crystal mask. In addition, the image area of the static image to be tested is larger than the incident area of the light emitted from the light emitting means at least on the surface of the liquid crystal mask. Further, the light receiving means may be light receiving means comprising a light receiving unit for receiving the light passed through the static image to be tested, which has a silicon pn junction, and an optical filter which is provided on a light receiving window of the light receiving unit so that it does not transmit a YAG laser beam but transmits the above light.

In the above-described construction, during rewriting of various static images for a mark (printing images) on the liquid crystal mask, the static image to be tested (the image for measuring light transmittance) and each of the various static images for a mark are displayed

at least once. In the displaying (displaying during rewriting), the actual light transmittance of the static image to be tested is measured, and compared with the optimum light transmittance so as to control the voltage for a static image applied to the liquid crystal. The applied voltage for a static image, of course, represents the applied voltage for the static image to be tested and the applied voltage for a static image for a mark.

On the other hand, during rewriting, all common terminals and segment terminals of the liquid crystal mask are made equipotential (referred to as "the attaining of an equipotential state" hereinafter) immediately after the static image to be tested is displayed, thereby removing substantially all afterimages. The displaying of the static image to be tested and the attaining of an equipotential state are performed at least once. However, the liquid crystal mask has the characteristic that the actual light transmittance increases as the application time of the voltage for displaying a static image increases. Therefore, in the present invention, the application of a voltage for a long time easily makes unstable the measurement of the actual light transmittance. When the attaining of an equipotential state is performed after the static image to be tested is displayed for a short time, therefore, a stable light

transmittance is obtained. Even with the attaining of an equipotential state having the above effect, if the displaying time is increased, the rising time of a static image on the liquid crystal mask is increased, thereby causing difficulties in high-speed printing.

In the present invention, therefore, after the static image to be tested is displayed and an equipotential state is attained, the same static image as a static image for a mark which is displayed after the termination of the rewriting time, is displayed, and an equipotential state is attained. The displaying of a static image for a mark and the attaining of an equipotential state are performed at least once up to the termination of the rewriting time so as to finally attain an equipotential state. As a result, an afterimage of the static image to be tested is securely be erased, and smooth rapid start of the displaying of a next static image for a mark can be secured after the termination of the rewriting time. The static image for a mark which is displayed during the rewriting, of course, represents an image having the same content as a first static image for a mark which is displayed after the termination of the rewriting time. It can thus be thought that the final displayed static image for a mark is left as it is after the termination of the rewriting time, and is used as a

next static image for a mark. In this thinking, the rewriting time should be considered to start before the displaying of the final static image for a mark, i.e., at the termination of the final attaining of an equipotential state.

As described above, the displaying of the static image to be tested and a static image for a mark during rewriting enables incorporation into the first and second proposals, and the maintenance of good printing accuracy and high printing speed.

In addition, since the image area of the static image to be tested is larger than the incident area of the light emitted from the light emitting means, the intensity of emitted light and the intensity of received light are accurately obtained, and good printing accuracy is maintained. Further, since the optical filter is provided on the light receiving means so as to shield the YAG laser beam (for printing) and transmit the light emitted from the light emitting means, the noise caused by the YAG laser can be removed, thereby enabling high-accuracy and high-speed printing.

Brief Description of the Drawings

Fig. 1 is a time table showing the outline of a marking cycle and the outline of repetition of interrupt

displaying in accordance with a first embodiment of the present invention;

Fig. 2 is a flowchart in accordance with the first embodiment;

Fig. 3 is a drawing illustrating the hardware configuration of a transmission type liquid crystal mask marker in accordance with the first embodiment;

Fig. 4 is a time chart showing operations during a rewriting time in accordance with the first embodiment, a second embodiment and an embodiment of an unpublished application;

Fig. 5 is a drawing illustrating the software configuration of a transmission type liquid crystal mask marker in accordance with a third embodiment of the present invention;

Fig. 6 is a graph showing the sensitivity characteristics of silicon photodiodes in accordance with prior art and the third embodiment;

Fig. 7 is a chart showing the reflectance characteristics of an optical filter of light receiving means in accordance with the third embodiment;

Fig. 8A is an oscilloscopic chart showing effects of noise on sensor output in accordance with the third embodiment; and

Fig. 8B is an oscilloscopic chart showing effects of

noise on sensor output in accordance with prior art.

Best Mode for Carrying Out the Invention

Transmission type liquid crystal mask markers in accordance with preferred embodiments of the present invention are described with reference to the attached drawings.

Referring Fig. 3 showing the hardware configuration of a first embodiment, laser beam L1 which is emitted from a laser oscillator 1 is first deflected to the direction Y by a galvanoscanner 9Y through a beam shaping device 81. The laser beam L1 is then deflected to the direction X by a polygon mirror 9X and applied to a converging lens 82. The converging lens 82 converges the laser beam L1 at substantially one point on a reflecting mirror 83, and, at the same time, scans a static image to be tested on a transmission type liquid crystal mask 2. The transmitted laser beam L2 which is transmitted through the transmission type liquid crystal mask 2 and which contains information of a static image for a mark is deflected by a reflecting mirror 83, and is applied to a surface of a workpiece 3 on a work feeder 10 through an objective lens 84. This irradiation marks a static image for a mark on the surface of the workpiece 3. In the above-described configuration, driving systems of the laser oscillator 1,

the X deflecting device 9X, the Y deflecting device 9Y, the liquid crystal mask 2 and the work feeder 10 are electrically connected to the controller 7 so as to be synchronously controlled by the controller 7.

A static image to be tested other than a static image for a mark is appropriately displayed on the liquid crystal mask 2 by applying a voltage from the controller 7. A light emitting element 5 serving as light emitting means and a light receiving element 6 serving as light receiving means are also provided. The light receiving element 6 receives the light emitted from the light emitting element 5 and passed through the static image to be tested, which is displayed on the liquid crystal mask 2, to output the intensity of received light R2 to the controller 7. It is thus preferable that the area of the static image to be tested is larger than the incident area of the light emitted from the light emitting element 5 at least on the surface of the liquid crystal mask 2. The light emitting element 5 and the light receiving element 6 are electrically connected to the controller 7 to be synchronously controlled by the controller 7. The controller 7 previously stores an optimum light transmittance Q_0 and the intensity of emitted light R1 emitted from the light emitting element 5. The optimum light transmittance Q_0 is a value which is previously

stored in the controller 7 on the basis of the measurements of the characteristics of the transmission type liquid crystal mask 2 of the transmission type liquid crystal mask marker in ordinary use.

The software configuration of the first embodiment is described below. As shown in Fig. 1, this embodiment relates to a transmission type liquid crystal mask marker of high-accuracy and high-speed continuous printing type having a printing cycle t of about 0.8 second. The printing cycle t includes a displaying time (printing time) t_1 of a static image for a mark of about 0.3 second, and a workpiece standby time (the time of movement and fixing at the printing position of workpiece) t_2 of about 0.5 second. In the workpiece standby time t_2 , i.e., the rewriting time t_2 , the interrupt displaying time t_{21} of the static image to be tested or a static image for a mark is about 0.1 second. The time for making 0 V all common terminals and segment terminals of the liquid crystal mask 2 (i.e., grounding all terminals), or the time t_{22} for attaining an equipotential state, after this interrupt displaying is about 0.04 second. In this embodiment, the displaying and the attaining of an equipotential state are repeated three times within the workpiece standby time t_2 . Fig. 2 is a flowchart showing the repetition.

In the displaying and the attaining of an

the X deflecting device 9X, the Y deflecting device 9Y, the liquid crystal mask 2 and the work feeder 10 are electrically connected to the controller 7 so as to be synchronously controlled by the controller 7.

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equipotential state in the first embodiment, the controller 7 first displays the static image to be tested during the rewriting time t_2 , as shown in Fig. 4. The controller 7 inputs the intensity of received light R_2 from the light receiving means 6 during the displaying time t_{21} of about 0.1 second. The actual light transmittance of the transmission type liquid crystal mask 2 is computed from the intensity of received light R_2 and the intensity of emitted light R_1 of the light emitting means 5. The controller 7 controls the voltage for a static image applied to the liquid crystal mask 2 so that the actual light transmittance Q is equal to the optimum light transmittance Q_0 . After the elapse of the displaying time t_{21} , all terminals are made 0 V to attain an equipotential state. After this attaining of an equipotential state, the same static image as the first static image for a mark after the termination of the rewriting time t_2 is displayed, and then an equipotential state is attained. After this attaining of an equipotential state, the elapsed time t from the start of rewriting is compared with the rewriting time t_2 . If $t < t_2$, the displaying of the static image to be tested, and the attaining of an equipotential state are repeated. If $t = t_2$, i.e., if it is decided that the rewriting time is terminated, a next regular static image for a mark is

displayed and printed.

Since the liquid crystal mask 2 is controlled to the optimum light transmission Q_0 by the above-described displaying and the attaining of an equipotential state, a next regular static image for a mark is printed on the work surface 3 with high accuracy. Since afterimages of the regular static image for a mark and the static image to be tested are securely erased before the start of rewriting, displaying of a regular static image for a mark after the end of rewriting can rapidly and smoothly be started. Although, in this embodiment, a static image is displayed three times, the static image may be displayed any desired times in accordance with the specifications of the body of the transmission type liquid crystal mask marker used.

A second embodiment of the present invention is described. In this embodiment, unlike the first embodiment, the displaying of the static image to be tested and the attaining of an equipotential state are repeated a plurality of times. Drawings similar to Figs. 1 and 3 of the first embodiment are not described.

In Figs. 3 and 4, the controller 7 first displays the static image to be tested and inputs the intensity of received light R_2 during the rewriting time t_2 . An equipotential state is then attained, and the number of

times n the static image to be tested is displayed is then compared with the predetermined number of times N the static image to be tested is displayed. If $n < N$, the displaying of the static image to be tested and the attaining of an equipotential state are repeated. If $n = N$, the same static image as the first static image for a mark after the end of the rewriting time t_2 is displayed. After this displaying, an equipotential state is finally attained at the end of the rewriting time t_2 , as in the first embodiment.

The second embodiment enables erasing of afterimages, stabilization of the intensity of received light R_2 , and more rapid and smooth start of the displaying of a next regular static image for a mark. Although, in this embodiment, the number of times a static image is displayed is 3, the number of times of displaying may be set to any number according to demand. For example, if the number of times of displaying is 5, the two times of earlier displaying may be performed for the static image to be tested, and the three times of later displaying may be performed for a static image for a mark. It is a matter of course that the number of times of earlier displaying and the number of times of later displaying may be reversed. Although the static image to be tested is displayed a plurality of times N , the

intensity of received light R2 may be input to the controller 7 at least once.

As is obvious from the first and second embodiments, when the controller having the aforementioned program is applied to a conventional transmission type liquid crystal mask marker, a program for maintaining printing accuracy can be incorporated without any difficulties. There is thus no need to change the configuration of the bodies of the transmission type liquid crystal mask marker and the work feeder. In addition, since the static image to be tested is displayed at a high speed, each of the embodiments is a help to increase the printing speed and the printing accuracy by increasing the operation speed of the conventional transmission type liquid crystal mask marker and the work feeder body. As a result, it is possible to maintain and further improve the high printing speed and printing accuracy, thereby permitting an attempt to increase the throughput.

An embodiment of another unpublished international application (Application No. PCT/JP94/00703) which has been proposed by the applicant of the present invention is described. This embodiment has the same hardware configuration as the first embodiment of the present invention, but the software configuration is different in the displaying of a static image and the attaining of an

equipotential state during the rewriting time. Namely, as shown in Fig. 4, the static image to be tested is displayed at the start of rewriting, the intensity of received light R2 is input from the light receiving means 6, and the voltage for a static image to be applied to the liquid crystal mask 2 is regulated so that the actual light transmittance Q is equal to the optimum light transmittance Q_0 . After the static image to be tested is displayed, an equipotential state is attained, and the displaying of the static image to be tested and the attaining of an equipotential state are repeated up to the termination of the rewriting time t_2 . As a result, afterimages are erased, the intensity of received light R2 (i.e., the actual light transmittance Q) is made stable, and the displaying of a next regular static image for a mark for printing is started at high speed.

In the unpublished application, the displaying of the static image to be tested and the attaining of an equipotential state are repeated. However, in the present invention, after the displaying of the static image to be tested and the attaining of an equipotential state are performed once, the displaying of a static image for a mark and the attaining of an equipotential state are repeated at least once. Since, in the present invention, the static image to be tested and a static image for a

mark are displayed, the start of a regular static image for printing is further improved, as compared with the unpublished application.

A transmission type liquid crystal mask marker in accordance with a third embodiment of the present invention is described below with reference to the attached drawings.

Fig. 5 shows the hardware configuration of a transmission type liquid crystal mask marker comprising a YAG laser with Q switch of the third embodiment. Points different from Fig. 1 of the first embodiment are described. The third embodiment is different from the first embodiment in the points that a deflecting lens 86 is provided between the galvanoscanner 9Y and the polygon mirror 9X, and that an optical filter 61 is provided on a light receiving window of the light receiving means 6 as light receiving element. When the deflecting lens 86 is provided, the laser beam L1 deflected to the direction Y by the galvanoscanner 9Y is deflected by the deflecting lens 86, and applied to substantially the same point on the polygon mirror 9X. Since the irradiation point can be controlled within a narrow range, the thickness of the polygon mirror 9X can be decreased. It is thus possible to decrease the weight of the polygon mirror 9X, increase the operation speed of the polygon mirror 9X and decrease

the size thereof. The basic function is similar to the transmission type liquid crystal mask marker (refer to Fig. 1) without the deflecting lens 86. The laser beam L1 applied to the polygon mirror 9X is passed through the liquid crystal mask 2 for displaying a static image for a mark to print the image on the workpiece surface 3 at a high speed with high accuracy, as in the first embodiment.

The light receiving means 6 provided with the optical filter 61 is described below. The light receiving means 6 receives the transmitted light emitted from the light emitting means 5 as a light emitting element, and outputs the intensity of the received light R2 to the controller 7. The controller 7 computes the actual light transmittance Q from the intensity of received light R2 and the intensity of emitted light R1, and controls the voltage for a static image applied to the liquid crystal 2 so that the actual light transmittance Q equals to the optimum light transmittance Q_0 . As a result, constant image printing quality is maintained.

The light emitting means 5 comprises a semiconductor laser which oscillates with a wavelength of 780 nm, and the light receiving unit of the light receiving means 6 comprises a silicon photodiode, and the optical filter 61 comprises a YAG laser deflecting filter. As shown in Fig. 7, the reflectance of the optical filter 61 within the

wavelength region of the YAG laser is not less than 90 %, and the reflectance within the wavelength region of the semiconductor laser is substantially 0. Namely, the optical filter 61 does not transmit the YAG laser beam L (transmitted laser beam L2), but transmits light R for measuring the light transmittance (light with the intensity of received light R2). The optical filter 61 is generally referred to as an "interference filter".

Figs. 8A and 8B show data examples of sensor output of this embodiment provided with the optical filter 61 and prior art (without the optical filter 61). Since sensor output B (prior art) contains the large noise caused during emission of the YAG laser beam L, the output value is unstable, and sensor output B is thus unsuitable for high-accuracy control. This is due to the noise caused by Q switch control of the YAG laser. However, noise is completely removed from sensor output C of this embodiment, and the intensity of received light R2 from the light emitting means 5 is stable. The transmission type light crystal mask marker is stably operated by driving control based on the sensor output C with an excellent S/N ratio, thereby preventing operation error. The image marking quality can also be maintained in a high level. In addition, although prior art has the need to decrease the effect of noise by disposing the optical

sensor (the light receiving element) at a position where the YAG laser beam is hardly applied, this embodiment eliminates such a limit and thus increases the degree of freedom of arrangement.

Industrial Applicability

The present invention can easily be applied to a conventional apparatus only by changing a program of the controller, and enables high-speed and high-accuracy stable printing by smoothly rising an image for printing while controlling the light transmittance of the liquid crystal mask to an optimum state, and an attempt to increase the throughput. The present invention is also useful as a transmission type liquid crystal mask marker which can remove noise by the optical filter to increase the S/N ratio of sensor output.



Claims

1. A transmission type liquid crystal mask marker comprising a laser oscillator, a transmission type liquid crystal mask for displaying various static images for a mark, and a controller connected to said transmission type liquid crystal mask so as to control an applied voltage for displaying the various static images for a mark so that the various static images for a mark are printed on a surface of a workpiece by applying the laser beam from said laser oscillator, which is transmitted through said transmission type liquid crystal mask, to the surface of said workpiece, characterized in that light emitting means and light receiving means are connected to said controller, said transmission type liquid crystal mask is a transmission type liquid crystal mask for successively rewriting and displaying the various static images for a mark and appropriately displaying a static image to be tested by applying a voltage from said controller, said light emitting means is light emitting means for applying light to the static image to be tested, said light receiving means is light receiving means for receiving the light transmitted through the static image to be tested, said controller is a controller for previously storing an optimum light transmittance, during rewriting of at least one of the various static images for a mark, performing at



least once the displaying of the static image to be tested and, after the displaying, the attaining of an equipotential state of all common terminals and segment terminals of said transmission type liquid crystal mask, in this order, performing at least once the displaying of the static image for a mark and the attaining of an equipotential state up to the termination of the rewriting time so that an equipotential state is finally attained, in this order, inputting the intensity of receiving light from said light receiving means during the displaying of the static image to be tested, computing the actual light transmittance of said transmission type liquid crystal mask from the intensity of receiving light and the intensity of emitted light of said light emitting means, and regulates the voltage for a static image applied to said transmission type liquid crystal mask so that the actual light transmittance equals to the optimum light transmittance.

2. A transmission type liquid crystal mask marker according to Claim 1, characterized in that the image area of the static image to be tested is larger than the incident area of the light emitted from said light emitting means at least on the surface of said transmission liquid crystal mask.



3. A transmission type liquid crystal mask marker according to Claim 1 or 2, characterized in that said liquid receiving means comprises a liquid receiving unit having a silicon pn junction for receiving the light transmitted through the static image to be tested, and an optical filter which is provided on a light receiving window of said light receiving unit so that it does not transmit a YAG laser beam but transmits the light transmitted through the static image to be tested.

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