

LASER MARKING SYSTEM AND LASER MARKING METHOD

The present invention relates to a laser marking system and method and concerns, in particular, a laser marking system and a laser marking method suitable for marking identification numbers, letters, and the like on workpieces in semiconductor fabrication processes.

Generally, when product numbers, other identification numbers, and letters are marked on workpieces by a laser marking apparatus, each of workpieces is placed just below a laser emitting opening. After the workpiece has been marked, it is unloaded. For apparatus of this type, various technologies that identify workpiece types and align marking positions have been proposed so as to improve the content and alignment of markings. In addition, to mark workpieces effectively, high speed marking technology that quickly changes the objects to be marked has been proposed (as Japanese Patent Laid-Open Publication No. 2-187288).

Although these technologies improve the appearance, speed, and alignment accuracy of markings, technologies that allow total operating efficiency with respect to workpiece conveying apparatus, operating type, or operation time to be improved in marking systems have not been yet disclosed. Thus, with these conventional technologies, a large number of workpieces cannot be effectively conveyed and quickly marked.

Generally, workpieces are marked by an ink jet system. In the ink jet system, a relative position between a workpiece and an ink jet nozzle is changed by a conveying apparatus. Thus, an interlocking operation between the conveying apparatus and the ink jet system is required (as disclosed in Japanese Patent Laid-Open Publication No. 57.14981).

In recent years, as the size of workpieces such as semiconductor devices is decreasing, smaller marking numbers and letters and higher marking accuracy are being required. Thus, instead of ink jet systems, laser marking systems are being studied. In a conventional laser marking apparatus, laser light generated by a laser oscillator is raster scanned

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over a mask surface in two directions by a deflector. The work surface is marked with laser light that penetrates the mask. In reality, an entire mark to be marked is divided into several mark blocks. These mark blocks are displayed on a liquid crystal mask. By raster scanning laser light onto the liquid crystal mask, the transmitted light is radiated to the work surface by the deflector. By repeating this operation sequence, the entire pattern is marked. This method is disclosed as Japanese Patent Laid-Open Publication No. 2-187287.

However, this laser marking apparatus requires deflectors that raster scan the laser beam to be entered into a pattern displayed on a mask in X and Y directions. When the laser light that has transmitted the mask is deflected in X and Y directions along the workpiece conveying line, another deflector that deflects the divided pattern blocks along the workpiece plane is required so as to combine these pattern blocks. Thus, deflecting and scanning drive systems are required in the X and Y directions not only in the path of the laser light travelling toward the mask but also in the path of the laser light which has passed through the mask. Thus, in this related art reference the scale of the apparatus is large and the number of items to be controlled is large.

In addition, according to the laser marking apparatus having a liquid crystal mask, different patterns are displayed on the mask, one after the other. The positioned accuracy of the marking depends on the dot pitch. In other words, a mark displayed on the mask depends on whether each dot thereof transmits laser beam. Thus, a positioned accuracy higher than the dot pitch cannot be obtained. Since the space between dots is not marked, the resultant mark becomes unclear.

An object of the present invention is to provide a laser marking system and method for maximising the efficiency of the entire operating timing of the marking operation against workpiece loading/unloading operation of a workpiece conveying apparatus, for marking a large number of workpieces in a short time, for easily dividing a marking image into marking image blocks and combining these blocks into the original image, and for providing high positioned accuracy of the marking.

According to a first aspect of the present invention, there is provided a laser marking system, comprising a laser marking apparatus having a first deflector for scanning laser light generated by a laser oscillator onto a mask surface, and a second deflector for radiating light transmitted through the mask onto a work surface, and workpiece conveying apparatus, the improvement comprising a conveying apparatus having a feeder unit, a feeder guide unit, and a feeder escape unit, the feeder unit being disposed at a radiating position of the laser marking apparatus, the feeder guide unit being disposed upstream of the feeder unit, the feeder escape unit being disposed downstream of the feeder unit, an installation plate for lifting the conveying apparatus up and down, a loader portion for loading a workpiece, an unloader portion for unloading a workpiece, a control portion for totally controlling the conveying apparatus, the installation plate, the loader portion, and the unloader portion through a communication line, a production management host computer for transmitting and receiving signals to and from the control portion so as to manage a marking process, and a marking data generating computer disposed in the laser marking apparatus.

The conveying apparatus may comprise the feeder unit, a first feeder guide and escape unit disposed on one side of the feeder unit, a second feeder guide and escape unit disposed on the opposite side of the feeder unit, a first loader and unloader portion disposed outside the first feeder guide and escape unit and adapted for loading and unloading a workpiece, and a second loader and unloader portion disposed outside the second feeder guide and escape unit for loading and unloading a workpiece.

The laser marking apparatus comprises a first deflector for scanning laser light radiated by the laser oscillator in one direction, a mask for displaying divided pattern blocks of a marking pattern corresponding to scanning lines of laser light scanned by the first deflector, a second deflector for deflecting scanned light selectively transmitted from the mask and radiating the scanned light that is the marking pattern to the surface of the workpiece, and control means for

causing the mask to display the divided pattern blocks, one after the other, and the second deflector to deflect scanned light of the divided pattern blocks to corresponding divided directions so as to mark a combined pattern scanned by the first deflector and the second deflector on the workpiece.

The laser marking apparatus may comprise a first optical system for directing laser light radiated by the laser oscillator into a plurality of paths, a plurality of masks disposed in the paths and adapted for displaying the same image at slightly different positions so as to fill the gaps between mask dots of one mask with mask dots from the same image on another mask, a first deflector disposed between the first optical system and the masks, a second optical system for combining light transmitted through the masks, a second deflector disposed downstream of the second optical system, and control means for marking a combined pattern scanned by the first deflector and the second deflector on the workpiece.

The masks for use in the laser marking apparatus are preferably transmission type liquid crystal masks.

According to the above-mentioned laser marking system, the production management host computer can individually control each unit and the installation plate of the conveying apparatus, the loader portion and the unloader portion, which loads and unloads workpiece corresponding to required operation and the operation time. As the marking apparatus marks workpiece at high speed, the workpiece can be correspondingly loaded and unloaded. Thus, the operational timing of the entire system can be optimally designed so as to mark a large number of workpieces in a short time.

According to the above-mentioned laser marking apparatus, divided pattern blocks into which a marking pattern is divided corresponding to for example the X direction are displayed and scanned on the mask, block by block. In this construction, since the first deflector scans the blocks only in one direction, the first deflector can be constructed of

for example only a polygonal mirror. The transmitted light from the mask is radiated to the workpiece surface by the second deflector. The X direction of the deflecting position on the workpiece surface by the second deflector is fixed, whereas the Y direction thereof is moved by a distance equal to the height of each pattern block when each divided pattern block has been scanned. Thus, the light incident on the mask is scanned in the X direction and the transmitted light is scanned in the Y direction. By combining the divided pattern blocks, the original pattern can be marked on each workpiece. Therefore, since the apparatus does not need to raster scan the laser light incident on the mask, the number of control items can be reduced, thereby improving control characteristics.

When each divided pattern block is displayed on a plurality of masks, the same block is displayed at different positions so as to fill the gap between mask dots of one mask with mask dots of the same block from the other mask. In addition, the laser light is divided and scanned on each mask and the transmitted light is combined in one direction. The combined light is transmitted to the second deflector and the combined pattern is marked on the workpiece. Thus, the position accuracy of marking, which depends on the pitch of the mask dots, can be improved.

According to a second aspect of the present invention, there is provided a laser marking method for raster scanning laser light radiated from a laser oscillator by a first deflector onto a mask surface, radiating transmitted light from the mask surface to the surface of a workpiece by a second deflector, loading an unmarked workpiece, and unloading a marked workpiece, the method comprising the steps of:

(1) clamping a workpiece on a feeder table of a feeder unit disposed at a marking radiating position, moving the feeder table and marking the workpiece, unclamping the workpiece from the feeder table, and moving the feeder table to an original position;

(2) moving a supply table of a feeder guide unit from a supply table original position to a loader portion, receiving a workpiece from the loader portion, clamping the workpiece on the supply table, moving the

supply table to the feeder unit, unclamping the workpiece from the supply table, supplying the workpiece to the feeder unit, and moving the feeder table to the feeder unit, and moving the feeder table to the feeder table original position; and

(3) moving an escape table of an escape unit from an escape table original position to the feeder unit, receiving a workpiece from the feeder unit, clamping the workpiece on the feeder escape table, moving the feeder escape table to an unloader portion, unclamping the workpiece from the feeder escape table, supplying the workpiece to the unloader portion, and moving the feeder escape table to the feeder table original position, wherein the steps (1) to (3) are totally controlled by a control portion that is adapted to receive and transmit signals from and to a production management host computer through a communication line.

Step (1) can be performed by displaying each divided pattern block equivalent to a scanning line, block by block, on the mask by the first deflector adapted for scanning the laser light radiated from the laser oscillator in one direction, deflecting the scanned light selectively transmitted from the mask and radiating the divided pattern block to the surface of the workpiece by the second deflector, controlling the second deflector so as to deflect the scanned light of the divided pattern block to a corresponding divided direction, and marking a combined pattern scanned by the first deflector and the second deflector on the work.

Step (1) can alternatively be performed by dividing the laser light radiated from the laser oscillator into a plurality of laser paths by a first optical system, displaying the same marking pattern on a plurality of masks disposed on the laser paths so as to fill the gaps between mask dots with the same marking pattern, scanning the divided laser light on the masks by the first deflector, combining transmitted light from the masks as a single beam by a second optical system, and marking the combined pattern on the workpiece.

In a further alternative method for performing step (1), the laser light radiated from the laser oscillator may be scanned across a mask, and thereafter divided into a plurality of laser paths by a first optical system. By recombining the optical paths with a slight offset in the X and Y directions, the image of the mask may be marked on the workpiece in two positions offset horizontally and vertically by a distance of substantially half the mask dot pitch, so as to fill in the gaps between mask dots on the workpiece.

According to the laser marking method, the same effects as the above-mentioned laser marking system can be obtained.

Examples of the system and method of the present invention will now be described in detail with reference to the accompanying drawings, in which:

Figure 1 is a perspective view showing a construction of a laser marking system according to a first embodiment of the present invention;

Figure 2 is a schematic perspective view for explaining a laser marking apparatus;

Figure 3 is a flow chart showing the operating process of a loader portion;

Figure 4 is a flow chart for showing the operating process of a feeder guide unit;

Figure 5 is a flow chart showing the operating process of a feeder unit;

Figure 6 is a flow chart showing the operating process of a feeder escape unit;

Figure 7 is a flow chart showing the operating process of an unloader portion;

Figure 8 is a timing chart showing the operation of the marking system according to the first embodiment;

Figure 9 is a schematic view for explaining a workpiece receiving operation of the feeder unit;

Figure 10 is a schematic view for explaining a workpiece marking operation;

Figure 11 is a schematic view for explaining a workpiece escape operation;

Figure 12 is a perspective view showing a marking system according to a second embodiment of the present invention;

Figure 13 is a schematic diagram showing a construction of a laser marking apparatus according to a third embodiment of the present invention;

Figure 14 is a schematic diagram for explaining a liquid crystal mask display pattern scanned by a first deflector;

Figure 15 is a flow chart showing the operating process of a laser marking apparatus;

Figure 16 is a timing chart showing an operation of the laser marking apparatus;

Figure 17 is a schematic diagram for explaining a marking pattern and divided pattern blocks;

Figure 18 is a schematic diagram for explaining a principal portion of a laser marking apparatus according to a fourth embodiment of the present invention; and

Figures 19A, 19B, and 19C are schematic diagrams for explaining mask display patterns and their combined pattern according to the fourth embodiment.

A first embodiment of the present invention will now be described, with reference to Figures 1 to 11.

Referring to Figure 2, an example of a laser marking apparatus according to the first embodiment of the present invention is shown. A laser beam radiated from a YAG laser oscillator, which is a light source, is radiated to an X direction deflecting mirror 2. The reflected light of the X direction deflecting mirror 2 is scanned by the X direction deflecting mirror 2 over a marking surface 10 for a predetermined angle in the X direction. The reflected light is radiated to a polygonal mirror 4

through a relay lens 3. As the polygonal mirror 4 is rotated, the marking surface is scanned in the Y direction, line by line. The laser light is converged to a desired size by a field lens 5. The converged light is transmitted to the marking surface 10 through a liquid crystal mask 6, a deflecting mirror 7, and a relay lens 9. Thus, the marking surface 10 is marked according to a pattern on the liquid crystal mask 6.

Figure 1 is a schematic diagram showing the overall construction of a laser marking system with the above-mentioned laser marking apparatus 48. A workpiece is conveyed by a conveying apparatus 14 so that the marking surface 10 is placed at a focus position of the relay lens 9 that is a laser emitting opening of the laser marking apparatus 48.

The conveying apparatus 14 comprises a feeder unit 16F, a feeder supply unit 16I, and a feeder escape unit 16E. The feeder unit 16F is disposed just below the relay lens 9 and adapted to convey a workpiece 12 to a marking position. The feeder guide unit 16I is disposed upstream of the feeder unit 16F. The feeder escape unit 16E is disposed downstream of the feeder unit 16F and adapted to convey a workpiece 12 that has been marked away from the feeder unit 16F. These units 16F, 16I, and 16E are disposed on an installation plate 18. The feeder unit 16F has a screw shaft 22F and a feeder table 24F. The feeder guide unit 16I has a screw 22I and a supply table 24I. The feeder escape unit 16E has a screw shaft 22E and an escape table 24E. The screw shafts 22F, 22I, and 22E are coaxially aligned in the conveying direction of the workpiece. The feeder table 24F, the supply table 24I, and the escape table 24E are threaded to the screw shafts 22F, 22I and 22E, respectively. The feeder table 24F, the supply table 24I, and the escape table 24E are movable in the axial directions of their respective screw shafts. Rotation drive motors 26F, 26I, and 26E are mounted to drive the screw shafts 22F, 22I, and 22E, respectively. A guide rail 28 is disposed in parallel with the screw shafts 22F, 22I, and 22E and adapted to guide the tables 24F, 24I, and 24E, which move therealong. The guide rail 28 passes through the tables 24F, 24I, and 24E so as to guide them. The feeder table 24F has a central

recess so as to engage only the edge portions of a workpiece 12. Each of the supply table 24I and the escape table 24E fit to the recess of the feeder table 24F so as to supply and remove a workpiece 12 to and from the feeder table 24F. The tables 24F, 24I, and 24E each have a stop, enabling them to transfer a workpiece 12 from one table to another. In other words, the workpiece 12 is first placed on the supply table 24I of the feeder guide unit 16I. The feeder guide unit 16I then advances towards the feeder unit 16F, and the workpiece 12 is transferred to the feeder unit 16F and placed on the feeder table 24F. The feeder guide unit 16I then returns to its original position. After the workpiece 12 is marked, the feeder escape unit 16E advances toward the feeder unit 16F and the escape table 24E enters the central recess, beneath the workpiece 12. The workpiece 12 is placed on the escape table 24E of the feeder escape unit 16E and conveyed to the downstream side of the line.

The installation plate 18, on which the conveying apparatus 14 is disposed, has a focal point adjusting mechanism 8 that allows a workpiece 12 to be positioned at the focal point of the relay lens 9. In the embodiment shown, a base plate 30 is disposed below the installation plate 18. The installation plate 18 is lifted up and down relative to base plate 30. The installation plate 18 is moved by a lifting drive motor 33 and a lifting screw 30. The lifting drive motor 33 is mounted on the base plate 30. The lifting screw 30 is engaged in a threaded bore in the installation plate 18. It should be appreciated that the lifting drive operation of the installation plate 18 may alternatively be performed by a hydraulic cylinder or any other suitable mechanism. By using the lifting drive, the focal position can be adjusted to suit workpieces of different thickness.

The base plate 30 is formed with a stock table 36 that is disposed along the units 16I, 16F, and 16E. A loader portion 38 is disposed to move perpendicular to the feeder guide unit 16I. The loader portion 38 supplies an unmarked workpiece 12 to the supply table 24I. An unloader portion 40 is disposed perpendicular to the feeder escape unit

16E. The unloader portion 40 receives a marked workpiece 12 from the escape table 24E. The loader portion 38 has a suction means that sucks, lifts and conveys a workpiece 12 from the stock table 36 to the feeder guide unit 16I. The unloader portion 40 has a suction means that sucks, lifts and conveys a workpiece 12 from the feeder escape unit 16E to the stock table 36.

The laser marking system further comprises a control portion 42, a production management host computer (hereinafter referred to as the host computer) 44, and a marking data generation computer (hereinafter referred to as the computer) 46. The control portion 42 integrally controls the conveying apparatus 14, the installation plate 18, the loader portion 38, the unloader portion 40, and the laser marking apparatus 48. The host computer 44 controls the marking objects and quantity of workpiece in the marking process. Data is transmitted and received among these apparatus and units through a communication line.

Data flows between the host computer 44 and the conveying apparatus 14 take place as follows: The host computer 44 transmits data with respect of a workpiece 12 to be marked to the conveying apparatus 14. The data includes a marking object, a number of times the marking operation is to be performed, and a size of each workpiece. The control portion 42 controls and drives the units 16I, 16F, and 16E of the conveying apparatus 14 and individual constructional elements of the loader portion 38 and the unloader portion 40, and so forth.

Data flows between the conveying apparatus 14 and the laser marking apparatus 48 take place as follows: Each workpiece is marked in response to a marking request signal, a marking data change request signal, a request data identification number (these signals flow from the conveying apparatus 14 to the laser marking apparatus 48), a workpiece conveying request signal (this signal flows from the laser marking apparatus 48 to the conveying apparatus 14), and an error occurrence informing signal (this signal flows between the conveying apparatus 14 and the laser marking apparatus 48).

The computer 46 of the laser marking apparatus 48 has a memory that stores a plurality of marking data that include marking objects and positions, and status settings of the laser marking apparatus 48. The marking data have been created by the operator. When the host computer 44 requests marking data through the laser marking apparatus 48, the computer 46 outputs the requested marking data.

The control portion 42 controls individual constructional elements of the conveying apparatus 14, in particular, the loader portion 38, the feeder guide unit 16I, the feeder unit 16F, the feeder escape unit 16E, and the unloader portion 40.

As shown schematically in Figure 3, an arm 38a with a suction pad at its tip is moved to a stock of unmarked workpieces 39 of the loader portion 38 (at step 100). With a sensor (not shown), the host computer 44 determines whether or not a workpiece 12 is present at the stock position 39 (at step 101). When no workpiece 12 is present at the stock position 39, the host computer 44 terminates the loading operation. When there is a workpiece 12 at the stock position 39, the arm 38a engages and clamps the workpiece 12 (at step 102). Next, the arm 38a moves to a clamping position above the retracted position of the feeder guide unit 16I (at step 103). The host computer 44 causes the arm 38a to stop until the supply table 24I arrives at the retracted position (at step 104). With the supply table 24I in this position, the host computer 44 causes the arm to lower the workpiece 12 to the supply table 24I. After having determined that the workpiece 12 has been clamped to the supply table 24I (at step 105), the host computer 44 unclamps the workpiece 12 from the loader portion 38 (at step 106). The host computer 44 repeats these steps for the remaining workpieces 12.

As shown in Figure 4, the feeder guide unit 16I moves the supply table 24I to the retracted, workpiece receiving position of the loader portion 38 (at step 200). The feeder guide unit 16I waits until the host computer has determined that a workpiece 12 has been supplied from the loader portion 38 (at step 201). When the workpiece 12 has been supplied

from the loader portion 38 (at step 201), the feeder guide unit 16I clamps the workpiece 12 to the supply table 24I (at steps 202 and 203). The supply table 24I moves toward the feeder unit 16F (at step 204). The supply table 24I stops at the workpiece transfer position of the feeder table 24F (at step 205). The host computer 44 determines whether or not the work 12 has been clamped on the feeder table 24F (at step 206). After performing the clamping operation, the feeder guide unit 16I unclamps the work 12 from the supply table 24I (at step 207). The feeder guide unit 16I repeats these steps from step 200.

As shown in Figure 5, the feeder unit 16F moves the feeder table 24F to a workpiece receiving position (at step 300). The feeder unit 16F waits until a workpiece 12 is supplied from the feeder guide unit 16I (at step 301). When the host computer 44 has determined that the workpiece 12 has been transferred to the feeder table 24F (at step 302), the feeder unit 16F clamps the workpiece 12 on the feeder table 24F (at step 303). The host computer 44 drives the laser marking apparatus 48, which marks the workpiece 12 (at step 303). While varying the marking position of the workpiece 12, the host computer 44 causes the laser marking apparatus 48 to mark the entire pattern on the workpiece 12 (at step 305). After the laser marking apparatus 48 has marked the pattern on the workpiece 12 (at step 306), the feeder unit 16F waits until the escape table 24E arrives at a workpiece receiving position within the central recess of the feeder table 24F, (at step 307). The host computer determines whether or not the escape table 24E has been positioned below the feeder table 24F and the workpiece 12 has been clamped to the escape table 24E (at step 308). After the workpiece 12 has been clamped to the escape table 24F, the feeder unit 16F unclamps the workpiece 12 from the feeder table 24F. Thus, the workpiece 12 has been transferred to the escape table 24F (at step 309). The feeder unit 16 repeats these steps from step 300 so as to wait until the next workpiece 12 is supplied.

As shown in Figure 6, the feeder escape unit 16E moves the escape table 24E to the workpiece receiving position (at step 400) and waits until the workpiece 12 is supplied (at step 401). When the workpiece 12 is supplied from the feeder table 24F, the feeder escape unit 16E clamps the workpiece 12 to the escape table 24E (at steps 402 and 403). The escape table 24E moves away from the feeder table 24F and stops at an unloading position (at steps 404 and 405). The host computer 44 determines whether or not the unloading portion 40 has unloaded the workpiece 12 (at step 406). Until the unloading portion 40 has unloaded the workpiece 12, the escape table 24E is held stationary. When the unloading portion 40 has unloaded the workpiece 12, the feeder escape unit 16E repeats these steps from step 400.

As shown in Figure 7, the unloading portion 40 moves an arm 40a with a suction pad to a marked workpiece unclamp position on the escape table 24E and waits (at steps 500 and 501). The host computer 44 determines whether or not the escape table 24E has arrived at the workpiece unload position (at step 502). When the escape table 24E has arrived at the workpiece unload position, the unloader portion 40 lowers the arm 40a so as to clamp the workpiece 12 by suction 12 (at step 503). The arm 40a moves upward and to a marked workpiece stock position 41 (at step 504). The arm 40a unclamps the workpiece 12 (at step 505). The unloading portion 40 repeats these steps.

The above-described operations of the conveying apparatus 14 and the laser marking apparatus 48 are controlled by the host computer 44 corresponding to a timing chart shown in Figure 8. To improve marking efficiency, the feeder unit 16F, which directly contributes to marking the workpiece 12, returns the feeder table 24F to the workpiece clamping position. The feeder unit 16F repeats these steps.

While the feeder unit 16F is operating for the marking operation, the table returning operation, or the like, the feeder guide unit 16I receives an unmarked workpiece 12 on the supply table 24I, moves the supply table 24I to the workpiece transfer position of the feeder unit

16F, and waits until the feeder unit 16F arrives at the workpiece transfer position. When the feeder unit 16F requests a workpiece 12, the feeder guide unit 16I transfers the workpiece 12 to the feeder unit 16F. The feeder guide unit 16I returns the supply table 24I to the loader position.

When the feeder guide unit 16I requests a workpiece 12, the loader portion 38 transfers the workpiece 12 to the supply table 24I of the feeder guide unit 16I. The arm 38a with the suction pad moves to the stock of unmarked workpiece 39 and grips the next workpiece 12. The arm 38a then moves across to the transfer position of the feeder guide unit 16I and waits.

The feeder escape unit 16E waits at a marking end position of the feeder unit 16F until a workpiece 12 has been marked. When the feeder unit 16F requests removal of the workpiece 12, the feeder escape unit 16E receives the marked workpiece 12 from the feeder unit 16F. The feeder escape unit 16E moves the escape table 24E to the unloading position. After unclamping the workpiece 12, the feeder escape unit 16E returns the escape table 24E to the marking end position of the feeder unit 16F.

When the feeder escape unit 16E requests the unloading portion 40 to unload the workpiece 12, the unloading portion 40 grips the workpiece 12 on the escape table 24E. The unloader portion 40 moves the arm 40a with the suction pad so as to pile the workpiece 12 onto the marked workpiece stock position 41. The unloading portion 40 then returns the arm 40a to the workpiece transfer position of the feeder escape unit 16E and waits for the next workpiece 12.

Next, with reference to Figures 9 to 11, operations of these units will be described.

Figure 9 shows operations of individual units where a workpiece 12 is being transferred from the supply table 24I to the feeder table 24F. The loader portion 38 prepared the next workpiece 12 to be conveyed. The escape table 24E is transferring a marked workpiece 12 to the unloading portion 40.

Figure 10 shows operations of individual units where a workpiece 12 is being marked on the feeder table 24F. The loading portion 38 is loading a new workpiece 12 on the supply table 24I. The unloading portion 40 waits until the workpiece 12 is marked.

Figure 11 shows operations of individual units where a marked workpiece 12 is being transferred from the feeder table 24F to the escape table 24E. The supply table 24I waits for the feeder table 24F so as to transfer a next workpiece 12.

The operating range of each unit is designated by the control portion 42 corresponding to the size of workpiece and marking objects that are received from the host computer 44. To designate a focal position corresponding to the thickness of each workpiece, the amount by which the installation plate 18 is to be moved is controlled by the focal point adjusting mechanism 33. Thus, the vertical installation plate 18 is brought to the required vertical position.

A laser marking system according to a second embodiment of the present invention will now be described with reference to Figure 12.

The construction of the second embodiment is basically the same as that of the first embodiment. Two units are opposed with the feeder unit 16F therebetween. These units each perform a guiding operation and an escaping operation. In other words, a first feeder guide and escape unit 16L is movably disposed on the left of the feeder unit 16F. A first unmarked workpiece stock pile 48L and a first marked workpiece stockpile 50 L are arranged on opposite sides of a moving table 24L of the first feeder guide and escape unit 16L. A first loader and unloader portion 52L is mounted next to the unmarked workpiece stockpile 48L and extends across the first unmarked workpiece stockpile 48L, the table 24L and the first marked workpiece stockpile 50L. Likewise, a second feeder guide and escape unit 16R is movably disposed to the right of the feeder unit 16F. A second unmarked workpiece stockpile 48R and second marked workpiece stockpile 50R are positioned on opposite sides of a moving table 24R of the second feeder guide and escape unit 16R. A second loader and unloader

portion 52R is mounted next to the second unmarked workpiece stockpile 48R, and extends across the second unmarked workpiece stockpile 48R, the table 24R, and the second marked workpiece stockpile 50R.

The feeder unit 16F receives a workpiece 12 from the first feeder guide and escape unit 16L. After the workpiece 12 has been marked, the feeder unit 16F transfers the workpiece 12 to the second feeder guide and escape unit 16R.

The feeder unit 16F receives a new workpiece 12 from the second feeder guide and escape unit 16R. After this workpiece 12 has been marked, the feeder unit 16F transfers it to the first feeder guide and escape unit 16L. Using this embodiment, a large number of workpieces 12 can be effectively marked.

A third embodiment of the present invention will now be described with reference to Figures 13 to 17.

As show in Figure 13, a laser marking apparatus 68 comprises a YAG laser oscillator 61, an optical lens 62, and first deflector 63. The YAG laser oscillator 61 is a laser light source. The optical lens 62 converges laser light. The first deflector 63 deflects and scans the converged laser light only in X direction. The first deflector 63 is a 36-sided polygonal mirror 63a. The polygonal mirror 63a has several constant speed modes that can be individually selected to suit each different workpiece type. In other words, each side of the polygonal mirror 63 is equivalent to a line scanned in the X direction of a liquid crystal mask 66, which will be described later. Each complete rotation of the polygonal mirror 63 allows the mask 66 to be scanned in the X direction 36 times.

The liquid crystal mask 66 receives laser light scanned by the first deflector 63 through a field lens 65 and displays a pattern that transmits or scatters the laser light so as to form a desired mark pattern. The liquid crystal 66 is referred to as a polymer compound liquid crystal mask. An example of the liquid crystal mask 66 is liquid crystal compound composed of liquid crystal and resin (as disclosed in

Japanese Patent Laid-Open Publication No. 2-96714). The liquid crystal mask 66 has a large number of parallel electrode lines on the front and rear surfaces thereof. The parallel electrode lines on the front surface are perpendicular to the parallel electrode lines on the rear surface. When a voltage is applied to a portion of liquid crystal, this portion transmits laser light. Otherwise, the liquid crystal scatters laser light. A liquid crystal that switches between light transmitting state and non-light transmitting state can be applied to the apparatus according to the present invention. An example of this liquid crystal is a TN type liquid crystal. With this the front and rear electrode lines, a corresponding pattern can be quickly displayed. The liquid crystal mask 66, which is composed of polymer compound liquid crystal, does not need a deflecting plate. In addition, the intensity of laser light that passes through the liquid crystal mask 66 is two or more times larger than that passing through a conventional liquid crystal mask. In this embodiment, the liquid crystal mask 66 has a horizontally elongated dot matrix formed of vertical columns of 8 dots and horizontal rows of 256 dots. The liquid crystal mask 66 is however not limited to this type or configuration. Instead, various types such as a liquid crystal mask with a dot matrix formed by columns of 16 dots and rows of 512 dots may be used.

The liquid crystal mask 66 displays a pattern to be marked as a sequence of divided pattern blocks. As shown in Figure 14, the width of each divided pattern block is equivalent to the width of one scanning line scanned by the first deflector 63. The pattern to be displayed on the liquid crystal mask 66 is controlled by a controller 70. As shown in Figure 17, an entire pattern 90 composed of a figure 91 and letters 92 has been stored as print information composed of 256 horizontal dots x 128 vertical dots in the main memory of the controller 70. With respect to the print information, "1" and "10" represent print portions and non-print portions, respectively. The entire pattern 90 is horizontally divided into 16 sections, to be referred to as pattern blocks A to P. The controller 70 causes the liquid crystal mask 66 to display the pattern blocks A to P, one after the other.

Referring again to Figure 13, second deflector 67 is disposed on the output side of the liquid crystal mask 66. The second deflector 67 deflects laser light transmitted through the liquid crystal mask 66 toward the surface of the workpiece 74 corresponding to the pattern formed on the mask. The second deflector 67 comprises an X direction deflector 7X and a Y direction deflector 7Y. The X direction deflector 7X is composed of a mirror that directly reflects laser light transmitted through the liquid crystal mask 66. The Y direction deflector 7Y is a lens that receives the laser light already deflected by the X direction deflector 7X and deflects it in the Y direction. The orientation of the second deflector 67 (Y direction) is not changed from a marking region of a pattern block until the block has been scanned on the liquid crystal mask 66. When a first pattern block has been scanned, the second deflector 67 is then moved to the marking region for the next pattern block. Likewise, the orientation of the second deflector 67 is not changed from the marking region of this second pattern block until this pattern block has been scanned.

The X direction deflector 7X has a drive motor 71 that aligns the reflected light on the X direction of the workpiece surface 74a. The Y direction deflector 7Y has driving means 72 and 73 that move the Y direction deflector 7Y along the Y direction of the marking surface 74a of the workpiece 74. The first drive means 72 is a motor that is driven by an operation timing command of the controller 70. The second drive means 73 is a horizontal moving table. These drive means 72 and 73 are connected through a link mechanism that is connected to an output shaft of the motor 72. The motor 72 moves the horizontal moving table 73 in the Y direction. In this embodiment, an objective lens 69 is disposed between the X direction deflector 7X and the Y direction deflector 7Y. Since the objective lens 69 is independent of the Y direction deflector 7Y, the size of the lens system of the second deflector 67 is decreased. In addition, this objective lens 69 prevents the marking from dislocating and the density of radiated laser light from decreasing.

CW oscillation of the YAG laser oscillator 61 is controlled by a Q switch. The Q switch employs acoustic and optical effect. The Q switch can decrease the oscillation intensity of the laser light so that the oscillation intensity is lower than the minimum value of laser energy that can mark a workpiece.

A light converging optical system for the first deflector 63, comprising a collimator lens 62, is disposed between the laser oscillator 61 and the polygonal mirror 63. When the beam diameter of the laser light radiated from the laser oscillator 61 is large, the collimator lens 62 converges the laser light so as to increase the energy density of the output beam.

The controller 70 controls the liquid crystal mask 66, the drive portion 63b of the first deflector 63, the Q switch of the laser oscillator 61, the drive portion 71 of the X direction deflector 7X in the second deflector 7, and the drive motor 72 of the Y direction deflector 7Y.

As shown in Figure 15, the computer 78 of the laser marking apparatus 68 generates an entire pattern to be marked on a workpiece 74. The overall pattern that is dot information composed of 0s and 1s is stored at a predetermined address group of the main memory (at step 600). The entire pattern information is divided into a plurality of horizontally elongated pattern blocks (at step 601). The controller 70 activates the laser oscillator 611 and the Q switch decreases the intensity of laser light radiated by the laser oscillator 61 (at step 602). One pattern block is sent from the main memory to a temporary memory of the controller 70 (at step 603). This pattern block is displayed on the liquid crystal mask 66 (at step 604). The width of each pattern block to be displayed corresponds to the width of each line that is scanned in the X direction by the polygonal mirror 63a at a time, and to the number of dots in each vertical column of the matrix of the mask 66.

The controller 70 moves the second deflector 67 in the marking direction of the workpiece 74 according to address information of a pattern block (at step 605). The Q switch causes the laser oscillator 61 to generate laser light (at step 606). The first deflector 63 rotates, and the laser beam scans the liquid crystal mask 66 (at step 607). After the controller 70 has determined that the first deflector 63 has scanned the divided pattern block (at step 608), the Q switch causes the intensity of laser oscillation to be reduced (at step 609).

The controller 70 repeats the steps 603 to 609 until all the pattern blocks have been successively extracted and scanned, namely the entire pattern has been marked on the workpiece 74 (at step 610). After the combined pattern has been marked, when there is no workpiece 74 to be marked, the controller 70 stops the oscillation of the laser oscillator 61 (at steps 611 and 612). On the other hand, when there is a further workpiece 74 to be marked, the controller 70 waits until that workpiece 74 is conveyed to the marking position (at step 613). When the same pattern is to be marked on the workpiece 74, the controller 70 again performs the pattern block extracting steps (at step 603). Thus, the entire pattern is marked on the workpiece 74.

When a different pattern is to be marked on the workpiece 70, a new entire pattern that is dot information is stored in the main memory of the controller 70 (at step 600). Thereafter, the controller 70 repeats the similar steps.

Assume that an entire pattern 90 composed of a figure 91 and letters 92 as shown in Figure 17 is stored in the main memory of the controller 70. In other words, marking information composed of 1s that are marking portions and 0s that are non-marking portions is stored in a memory space of 256 horizontal dots x 128 vertical dots of the main memory. The marking information is divided into sixteen horizontally elongated pattern blocks A to P. As shown in Figure 16, the controller 70 controls the following operations. The liquid crystal mask 66 sequentially displays the sixteen pattern blocks A to P, one after the

other (operation 1). The X direction deflector 7X of the second deflector 67 moves to the marking position of the workpiece 74, and remains at this position until the entire pattern has been marked on the workpiece 74 (operation 2). The Y direction deflector 7Y of the second deflector 67 moves to the marking start position and remains at this position while the first divided pattern block A is displayed on the liquid crystal mask 66 (operation 3). When the next pattern block B is displayed on the liquid crystal mask 66, the Y direction deflector 7Y moves to deflect laser light by an amount corresponding to the pitch into which the entire pattern was divided, and scans the workpiece 74 so as to mark the workpiece 74 at the marking position adjacent to that of the marked pattern block A (operation 3'). This operation (3') is performed whenever the display pattern block on the liquid crystal mask 66 is changed. During these operations, the first deflector 63 scans the pattern block displayed on the mask 66 in the X direction and radiates the transmitted laser light to the second deflector 67 (operation 4). The laser oscillator 61 oscillates only while the first deflector 63 scans each pattern block in the X direction (operation 5). While the pattern block is being changed, the oscillation intensity is decreased by the operation of the Q switch.

The controller 70 receives a signal from a drive motor 75a which controls the movement of a table 75 on which a large number of workpieces 74 are placed, and signals from sensors 76 and 77 detect whether or not a workpiece 74 has arrived at a predetermined marking position. The controller 70 adjusts the operation timing to the table 75 and causes the same entire pattern that is a composite pattern to be marked on each workpiece 74.

According to this embodiment, since laser light that is radiated to a pattern displayed on the liquid crystal mask 66 is scanned only in one direction, the scanning control mechanism and the control operations thereof become very simple, thereby increasing the marking speed. In addition, the YAG laser does not apply much heat to the optical system. The first deflector 63 performs so-called pin-point radiation unlike

conventional diffused radiation due to beam spreading. Thus, the laser radiation to the liquid crystal mask 66 is equalised and intensified. Moreover, since the laser oscillator 61 has the Q switch, and can reduce intensity during non-scanning intervals, the peak value of the irradiated laser intensity can be increased. Furthermore, since the liquid crystal mask 66 does not need a deflecting plate, the intensity of transmitted laser light is two or more times higher than that of the conventional apparatus. Thus, in addition to the decrease in the size of the YAG laser oscillator 61, the intensified laser beam is scanned to the liquid crystal mask 66 in one direction, thereby clearly marking each workpiece.

The second deflector 67 can mark a large combined pattern on each workpiece 74 without the need to move the workpiece 74. Since the light converging optical system converges deflected incident laser light from a large diameter beam into a sharp laser beam, the deformation and deflection of marking, laser loss, and so forth can be reduced. In addition, the size of each deflector can be reduced. The controller 70 optimally controls the driving of the first deflector 63, the display switching of the liquid crystal mask 66, the driving of the second deflector 67, and the timing of the operation of the Q switch. In particular, the Q switch allows the oscillation intensity of laser light to be decreased when it is not necessary for marking a workpiece, thereby preventing the laser beam from scattering to other portions of the system. Thus, the system can mark workpieces that are made of metal, ceramic, and other materials with a combined pattern. In addition, the apparatus can be prevented from being damaged by high intensity laser light.

A fourth embodiment of the present invention will now be described with reference to Figures 18 and 19A to 19C.

The construction of the fourth embodiment is substantially the same as that of the third embodiment, except for a laser light input portion and a laser light output portion including the liquid crystal mask 66 of the third embodiment shown in Figure 13 are modified so as to

improve marking alignment accuracy of laser beam. The same portions as the third embodiment are denoted by the same reference numerals and their description is omitted.

As shown in Figure 18, a laser light beam from the laser oscillator 61 is transmitted to a beam splitter 80 through an expander lens 86, forming a first optical system as shown in Figure 18. The beam splitter 80 divides the laser light into two optical paths. In this optical system, a first liquid crystal mask 81 and a second liquid crystal mask 82 are provided. The first liquid crystal mask 81 that is disposed in the first optical path receives the light transmitted through the beam splitter 80. The second liquid crystal mask 82 receives the light reflected by the beam splitter 80 and by a mirror 83 disposed in the second optical path. The output rays of light of the first and second liquid crystal masks 81 and 82 are combined by a second mirror 84 and a second beam splitter 85 that form a second optical system. The combined light is radiated to a workpiece 74 through a focusing condenser lens 87.

Although the display pattern of the first liquid crystal mask 81 is the same as a display pattern of the second liquid crystal mask 82, the display portion of the first liquid crystal mask 81 is slightly offset from the display portion of the second liquid crystal mask 82 in the X and Y directions, so that the gaps between the dots of the display pattern on mask 81 are filled by dots of the display pattern of the second liquid crystal mask 82. In other words, although the display pattern of the first liquid crystal mask 81 is the same as the display pattern of the second liquid crystal mask 82 as shown in Figures 19A and 19B, the display pattern of the first liquid crystal mask 81 is offset downwards and to the left, and the display pattern of the second liquid crystal mask 82 is offset upwards and to the right. The combined pattern is displayed so that the gaps between mask dots of the first mask 81 are substantially filled by the dots of the second liquid crystal mask as shown in Figure 19C. The display positions of the first and second liquid crystal mask 81 and 82 may be offset either when they are fabricated, or by adjusting

their positions in use. For the first and second liquid crystal masks 81 and 82, transmission mask type compound dispersing liquid crystal is used. When a suitable optical system is used, another type of liquid crystal masks such as TN liquid crystal may be used.

When such as arrangement is applied to the laser marking apparatus shown in Figure 13, the beam splitter 80 and the mirror 83 are disposed on the input side of the first deflector 63. In addition, a pair of first deflectors 63 are provided so as to scan the first and second liquid crystal masks 81 and 82 separately. Moreover, the mirror 84 and the beam splitter 85 are disposed on the input of the second deflector 67. The combined pattern received from the second deflector 67, is marked on the workpiece 74.

Since the gap between mask dots of the transmitting type liquid crystal mask are filled, each workpiece can be clearly marked and marking position accuracy can be improved.

In an alternative embodiment, not illustrated, the laser light transmitted through a mask can be divided into a plurality of laser paths by a first optical system. By recombining the optical paths with a slight offset in the X and Y directions, the image of the mask may be marked on the workpiece in two positions offset horizontally and vertically by a distance of substantially half the mask dot pitch, so as to fill in the gaps between mask dots on the workpiece. Such an arrangement allows the gaps to be filled in, but requires only one mask and its associated driving circuitry.

According to the present invention, since entire operation time between workpiece loading and unloading operations of a workpiece conveying apparatus and marking operation of a marking apparatus is optimally designated, a large number of workpieces can be marked in a short time. In particular, when pattern blocks are displayed sequentially on a mask so as to mark a workpiece, the marking position accuracy is improved and the marking operation can be easily performed.



CLAIMS

1. A laser marking system, comprising:
 - a laser marking apparatus having a first deflector for raster scanning a laser light beam generated by a laser oscillator onto a mask surface, and a second deflector for radiating light transmitted through the work onto a work surface; and
 - a work conveying apparatus,
 - characterised by comprising:
 - a conveying apparatus having a feeder unit, a feeder guide unit, and a feeder escape unit, said feeder unit being disposed at an irradiating position of said laser marking apparatus, said feeder guide unit being disposed upstream of said feeder unit, said feeder escape unit being disposed downstream of said feeder unit;
 - an installation plate for vertical adjustment of said conveying apparatus;
 - a loader portion for loading workpiece;
 - an unloader portion for unloading said workpiece;
 - a control portion for totally controlling said conveying apparatus, said installation plate, said loader portion, and said unloader portion through a communication line;
 - a production management host computer for transmitting and receiving signals to and from the said control portion so as to manage a marking process, and a marking data generating computer disposed in said laser marking apparatus.
2. The laser marking system as set forth in claim 1, wherein said conveying apparatus comprises:
 - said feeder unit;
 - a first feeder guide and escape unit disposed on one side of said feeder unit;
 - a second feeder guide and escape unit disposed on the opposite side of said feeder unit;



a first loader and unloader portion disposed outside said first feeder guide and escape unit and adapted for loading and unloading a workpiece; and

a second loader and unloader portion disposed outside said second feeder guide and escape unit for loading and unloading a workpiece.

3. The laser marking system as set forth in claim 1, wherein said laser marking apparatus comprises:

a first deflector for scanning laser light radiated by said laser oscillator in one direction;

a mask for successively displaying pattern blocks of a marking pattern corresponding to scanning lines of laser light scanned by said first deflector;

a second deflector for deflecting scanned light selectively transmitted through said mask and irradiating with the surface of said workpiece the scanned light in said marking pattern; and

control means causing said mask to display said pattern blocks, one after the other, and causing said second deflector to deflect scanned light of each of said pattern blocks to a corresponding location on the workpiece surface so as to mark a combined pattern scanned by said first deflector and said second deflector on said workpiece.

4. The laser marking system as set forth in claim 1, wherein said laser marking apparatus comprises:

a first optical system for directing laser light radiated by said laser oscillator into a plurality of paths;

a plurality of masks each disposed in one of said paths and adapted for displaying the same image at slightly offset positions so as to substantially fill the gaps between mask dots of a first mask with mask dots of a second mask displaying the same image when the laser light is recombined;

a first deflector disposed between said first optical system and said masks;



a second optical system for combining light transmitted through said masks;

a second deflector disposed downstream of said second optical system; and

control means for marking a combined pattern scanned by said first deflector and said second deflector on said workpiece.

5. The laser marking system as set forth in claim 3 or claim 4, wherein said mask or masks is or are transmission type liquid crystal masks.

6. A laser marking method for scanning a laser light beam radiated from a laser oscillator by a first deflector onto a mask surface, radiating transmitted light through said mask surface to the surface of a workpiece via a second deflector, loading an unmarked workpiece, and unloading a marked workpiece, said method comprising the steps of:

- (1) clamping a workpiece on a feeder table of a feeder unit disposed at a marking radiating position, and marking said workpiece, unclamping said work from said feeder table, and moving said feeder table to an original position;
- (2) moving a supply table of a feeder guide unit from a supply table original position to a loading station, receiving a workpiece from said loading station, clamping said workpiece on said supply table, moving said supply table to said feeder unit, unclamping said workpiece from said supply table, supplying said workpiece to said feeder unit, and moving said feeder table to said feeder table original position; and
- (3) moving an escape table of an escape unit from an escape table original position to said feeder unit, receiving a workpiece from said feeder unit, clamping said workpiece on said feeder escape table, moving said feeder escape table to an unloading station, unclamping said workpiece from said feeder escape table, supplying said workpiece to said unloading station, and moving said feeder escape table to said feeder table original position



wherein said steps (1) to (3) are totally controlled by a control portion that is adapted to receive and transmit signals from and to a production management host computer through a communication line.

7. The laser marking method as set forth in claim 6, wherein said step (1) is performed by sequentially displaying pattern blocks each equivalent to a scanning line, block by block, on said mask and scanning them by said first deflector adapted for scanning the laser light radiated from said laser oscillator in one direction, deflecting the scanned light selectively transmitted through said mask and radiating the pattern block sequentially to the surface of said workpiece by said second deflector, controlling said second deflector so as to deflect the scanned light from each pattern block to a corresponding location on the workpiece surface to mark a combined pattern scanned by said first deflector and said second deflector on said workpiece.

8. The laser marking method as set forth in claim 6, wherein said step (1) is performed by dividing the laser light radiated from said laser oscillator into a plurality of laser paths by a first optical system, displaying the same marking pattern on a plurality of mutually offset masks disposed on said laser paths so that mask dots from a first mask substantially fill the gaps between mask dots of a second mask with the same marking pattern, scanning the divided laser light on said masks by said first deflector, combining the transmitted light of said masks as a single beam by a second optical system, and marking the combined pattern on said workpiece.

9. The laser marking method as set forth in claim 6, wherein said step (1) is performed by displaying the marking pattern on a mask disposed in said laser path, scanning the laser light on said mask by a first deflector, dividing the laser light radiated from said laser oscillator and through the mask into a plurality of laser paths by a first optical system, recombining the transmitted light of said masks as a single beam by a second optical system so that mask dots from a first mask image associated with a first optical path substantially fill the gaps between



mask dots of a second mask image associated with a second optical path, and marking the recombined pattern on said workpiece.

10. A laser marking system, substantially as described herein or with reference to the accompanying drawings.

11. A laser marking method, substantially as described herein.

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ABSTRACTLASER MARKING SYSTEM AND LASER MARKING METHOD

A laser marking system and a laser marking method for setting an overall operational timing between a workpiece conveying apparatus and a marking apparatus to maximum efficiency. The present invention provides a laser making system, comprising a laser marking apparatus having a first deflector for scanning a laser light generated by a laser oscillator on a mask surface and a second deflector for radiating light transmitted therethrough onto a workpiece surface, and a workpiece conveying apparatus, wherein a conveying apparatus (14) having a feeder unit (16F), a feeder guide unit (16I) is disposed at a radiating position of the laser marking apparatus, the feeder guide unit (16I) being disposed upstream of the feeder unit (16F), the feeder escape unit (16E) being disposed downstream of the feeder unit (16F), an installation plate (18) for lifting the conveying apparatus up and down, a loader portion (38) for loading a workpiece (12), an unloader portion (40) for unloading the workpiece (12), a control portion (42) for totally controlling said conveying apparatus, said installation plate (14), said loader portion (38), and said unloader portion (40) through a communication line, a production management host computer (44) for transmitting and receiving signals to and from said control portion (42) so as to manage a marking process, and a marking data generating computer disposed in said laser marking apparatus. Thus, a large number of workpieces can be marked in a short time.

Figure 1

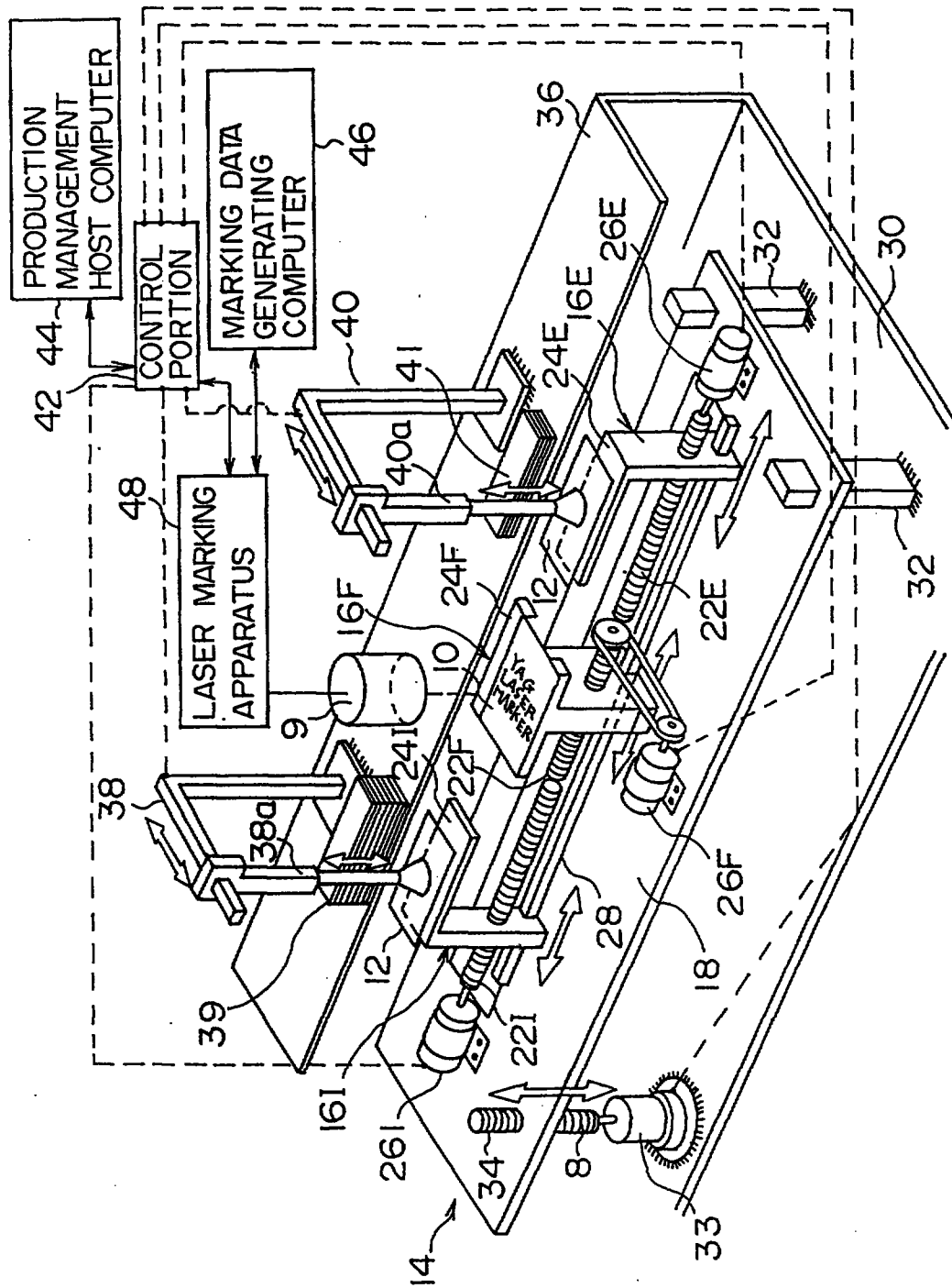


FIG. 1

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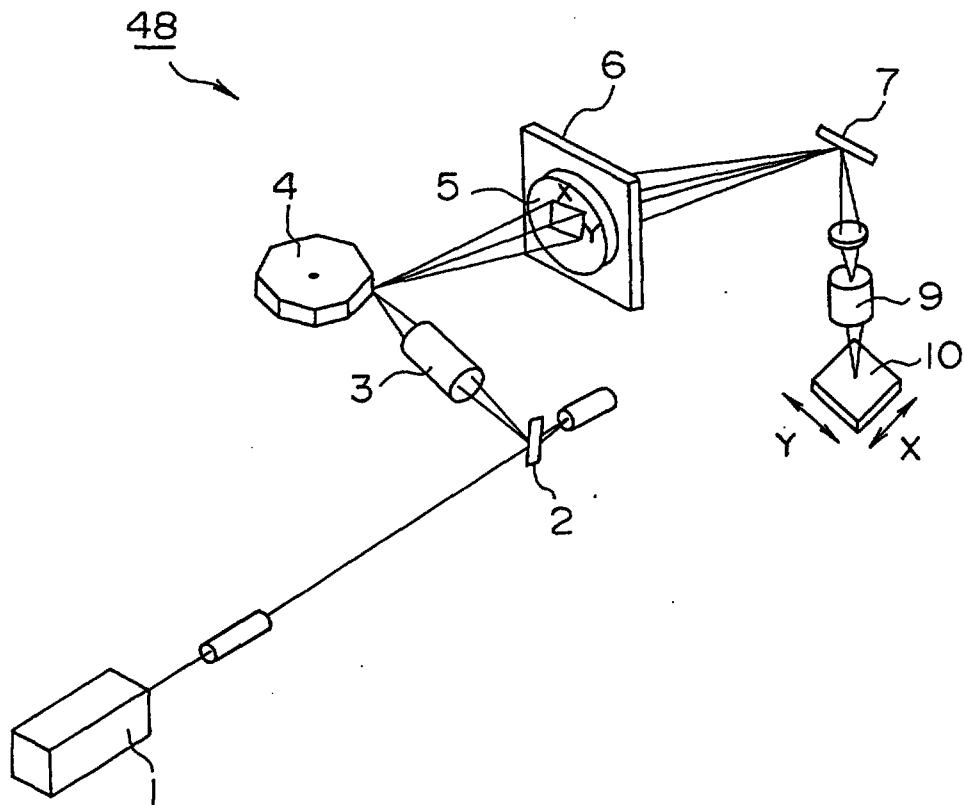


FIG. 2

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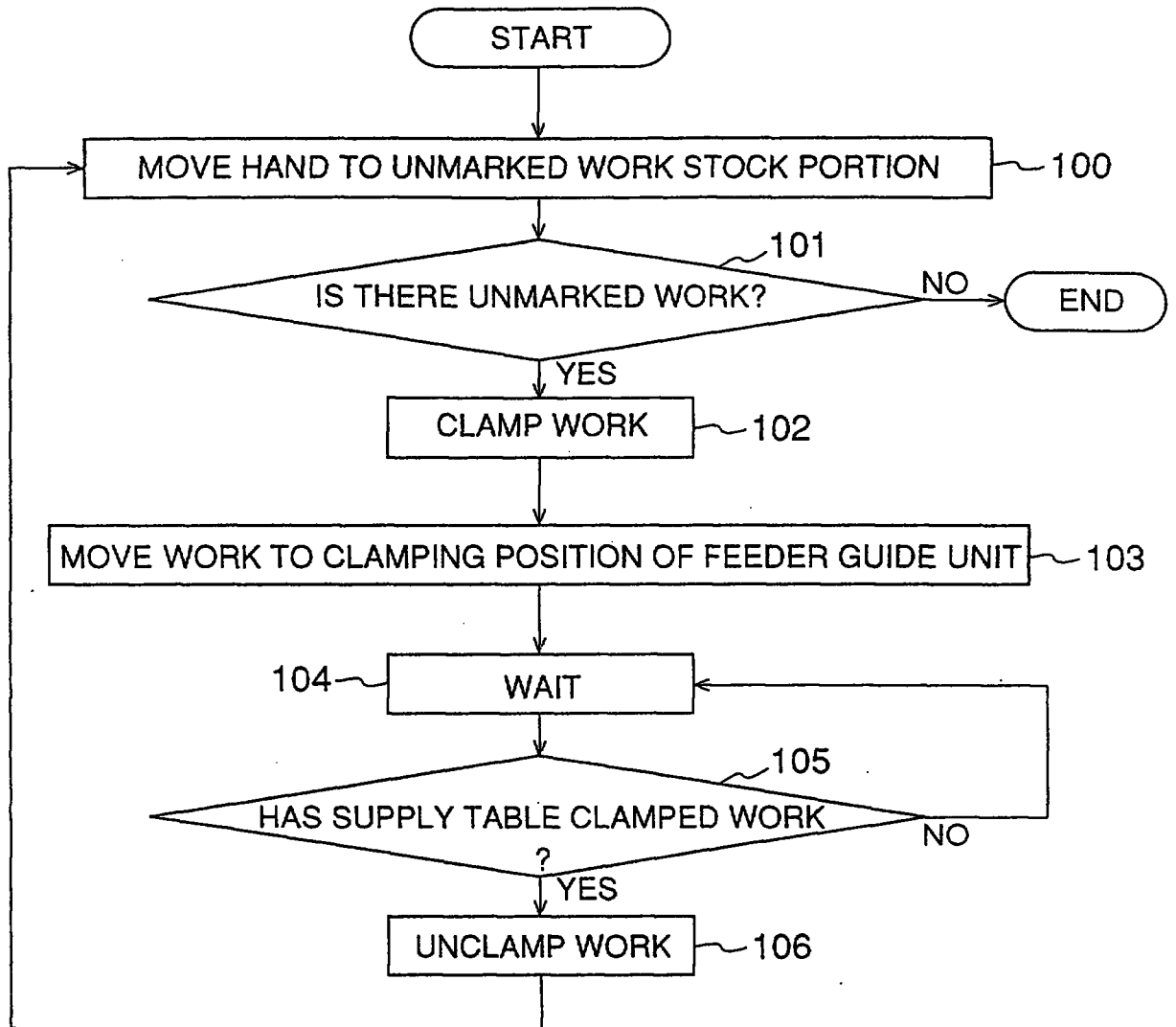


FIG.3

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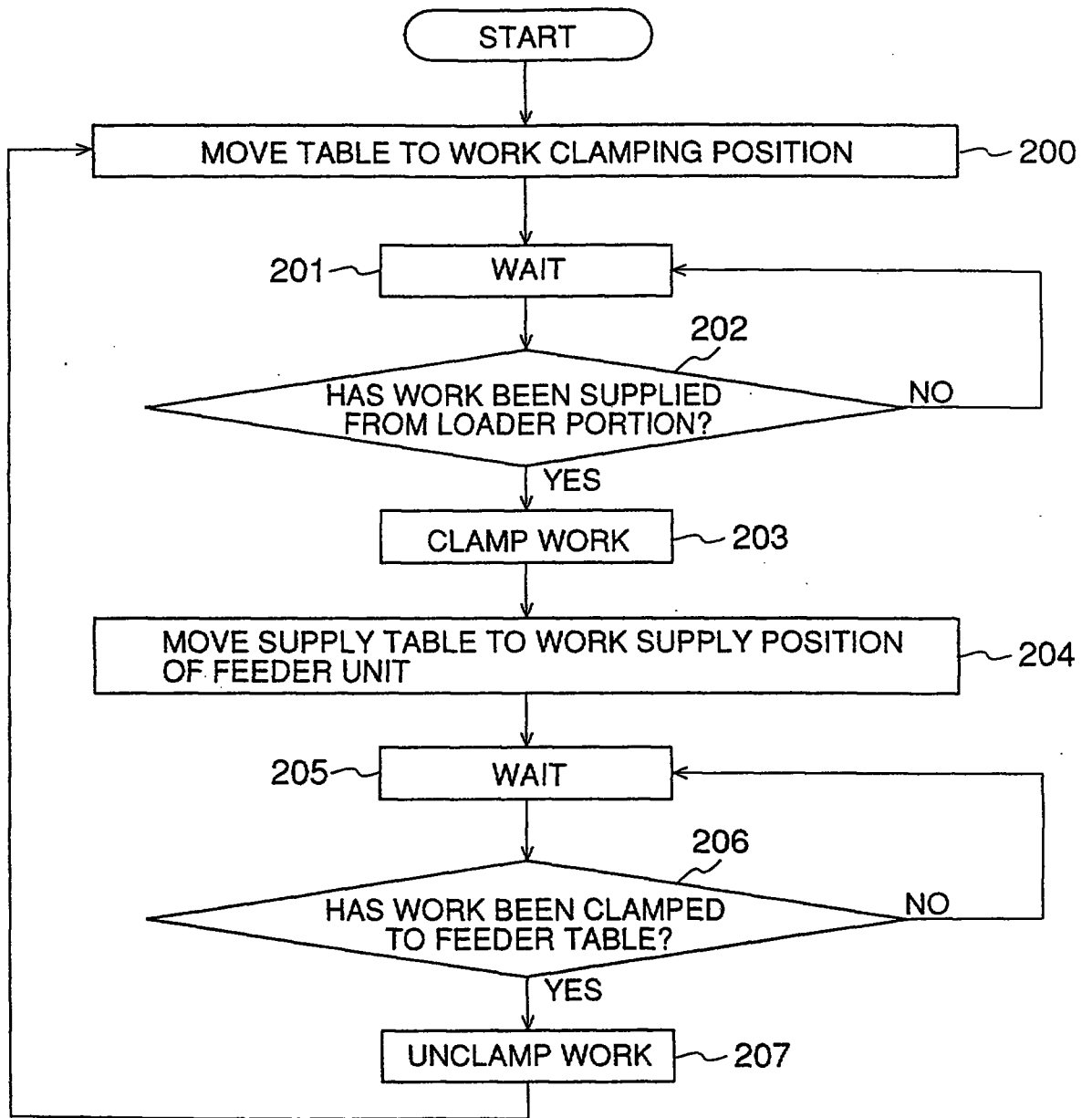


FIG.4

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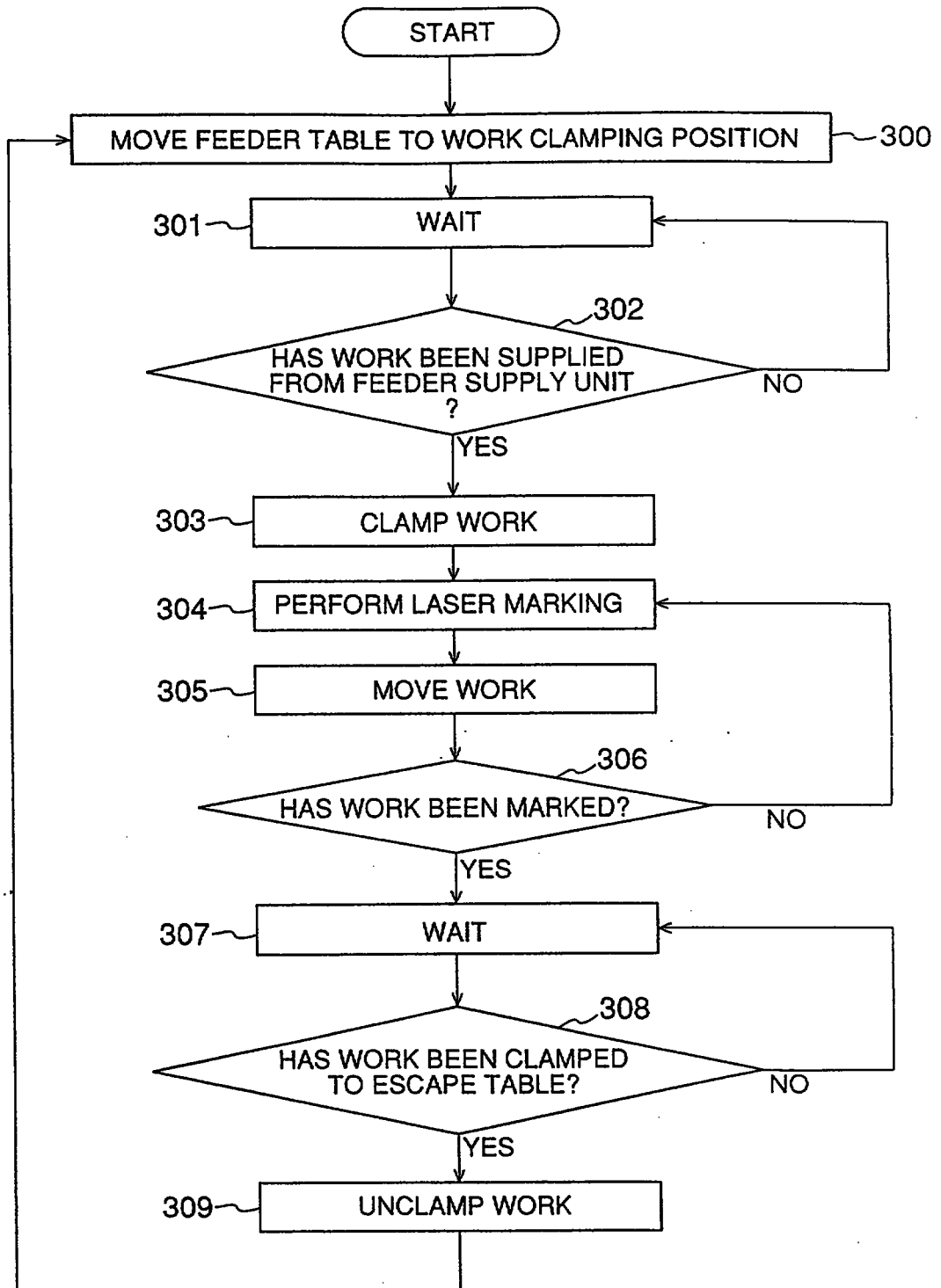


FIG.5

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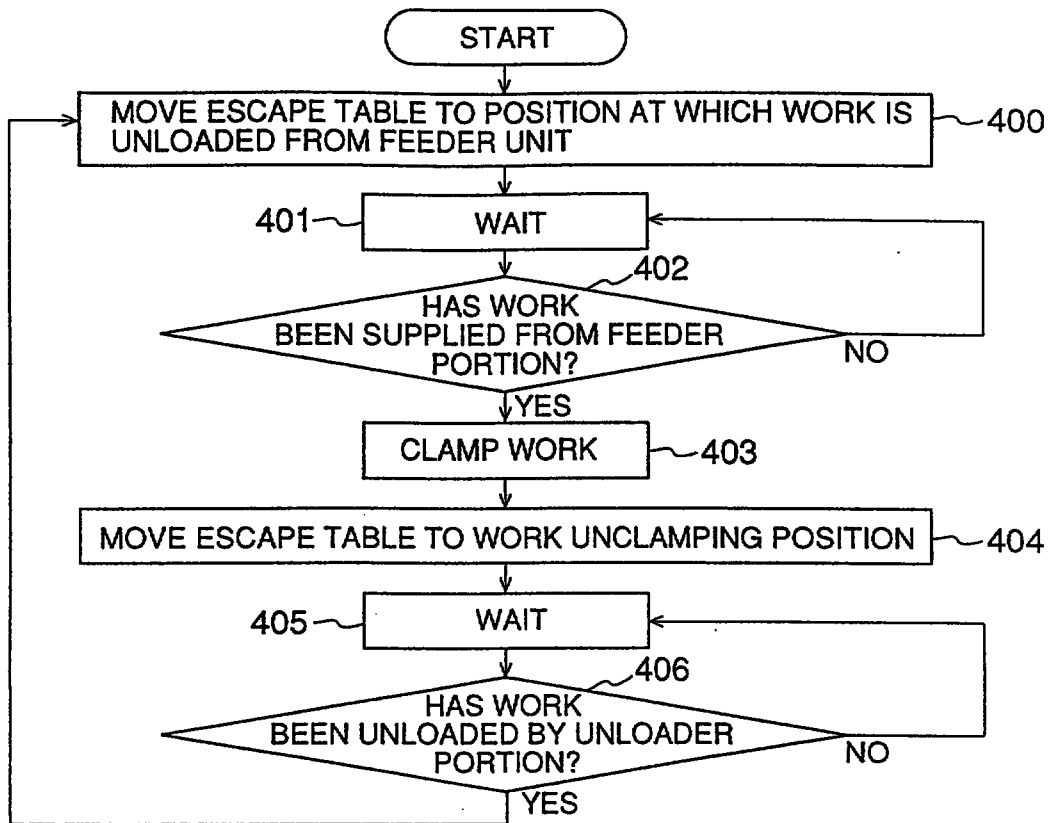


FIG.6

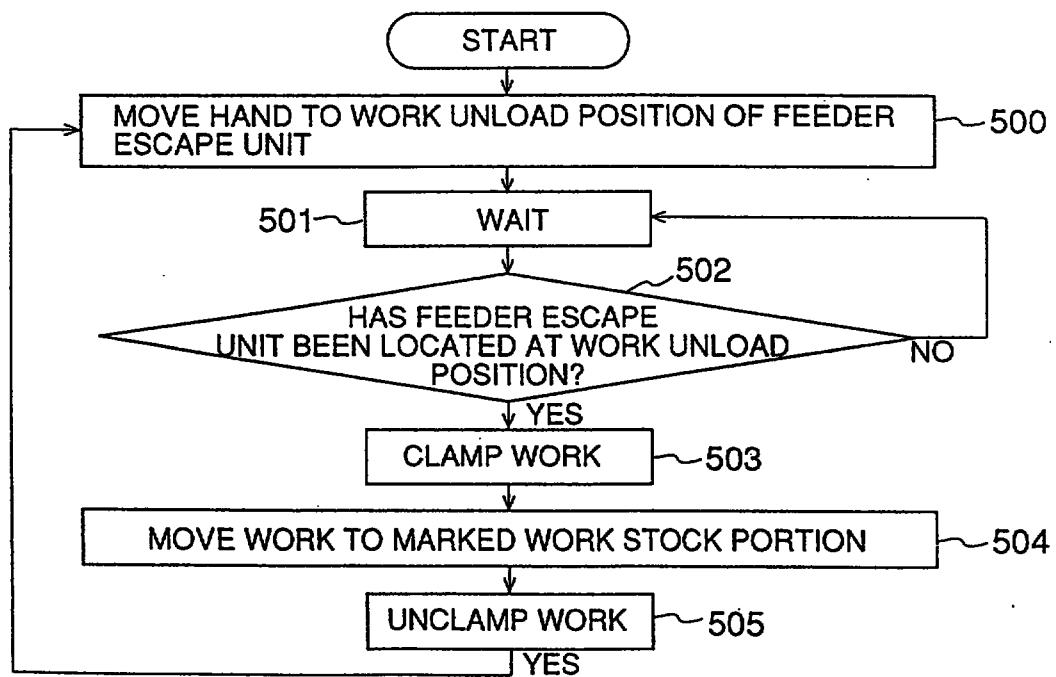


FIG.7

[illegible]

FIG. 8

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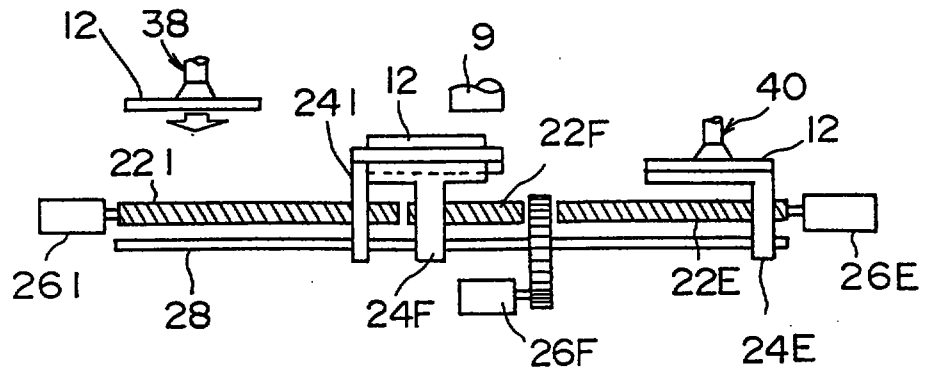


FIG. 9

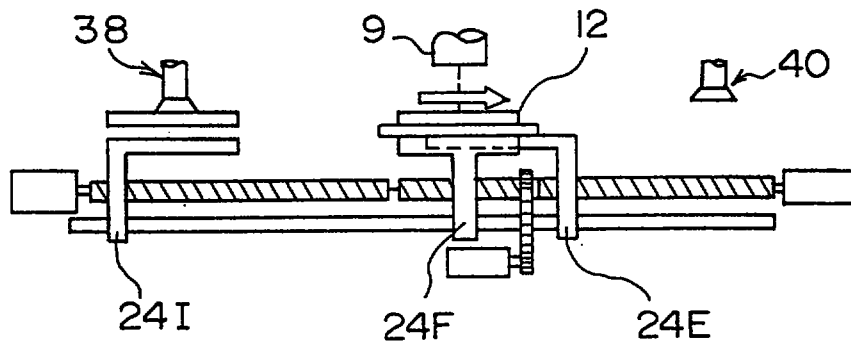


FIG. 10

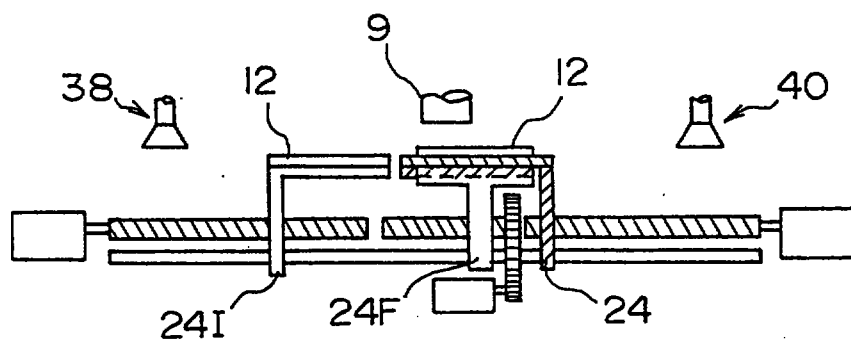


FIG. 11

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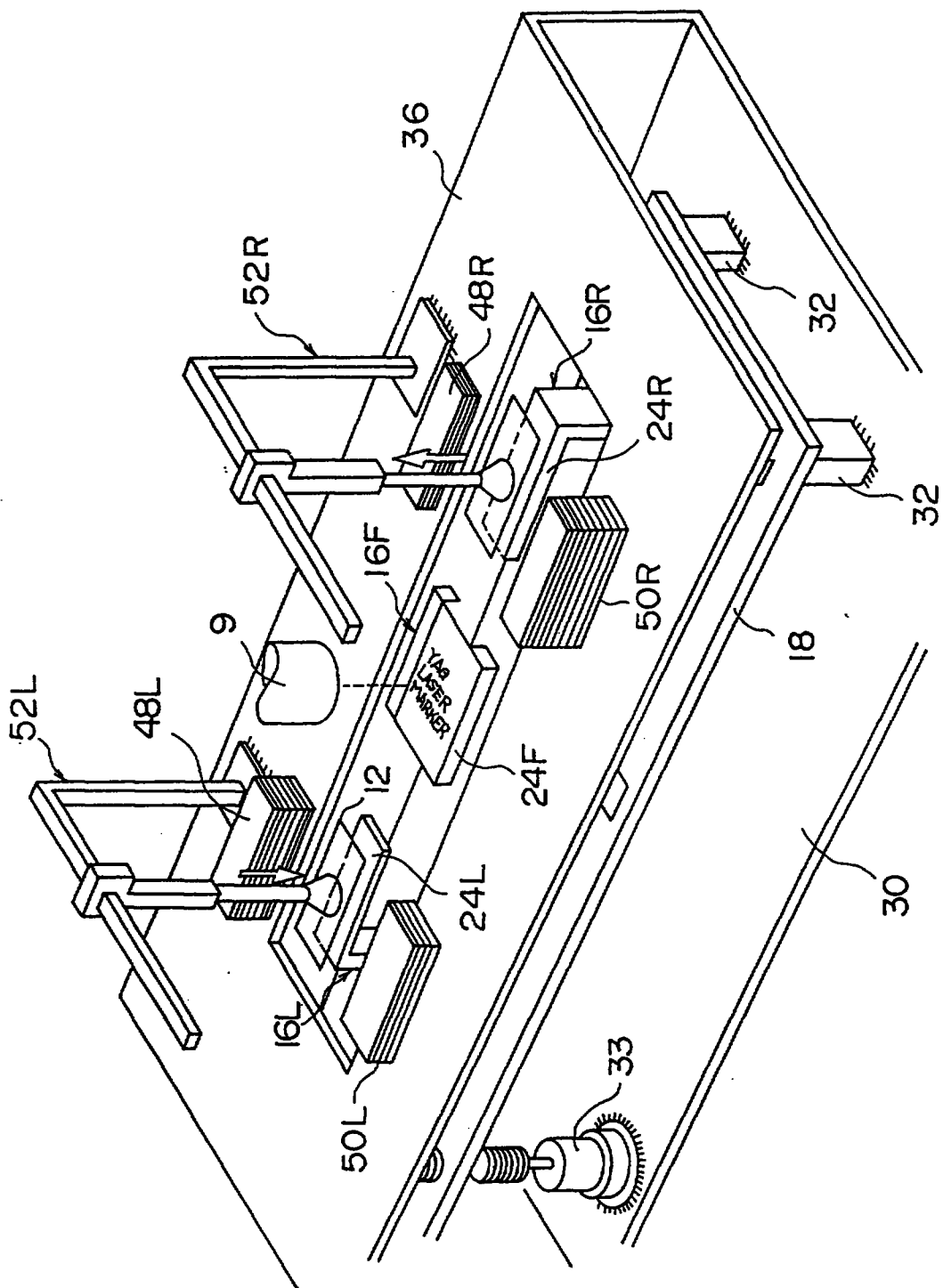


FIG. 12

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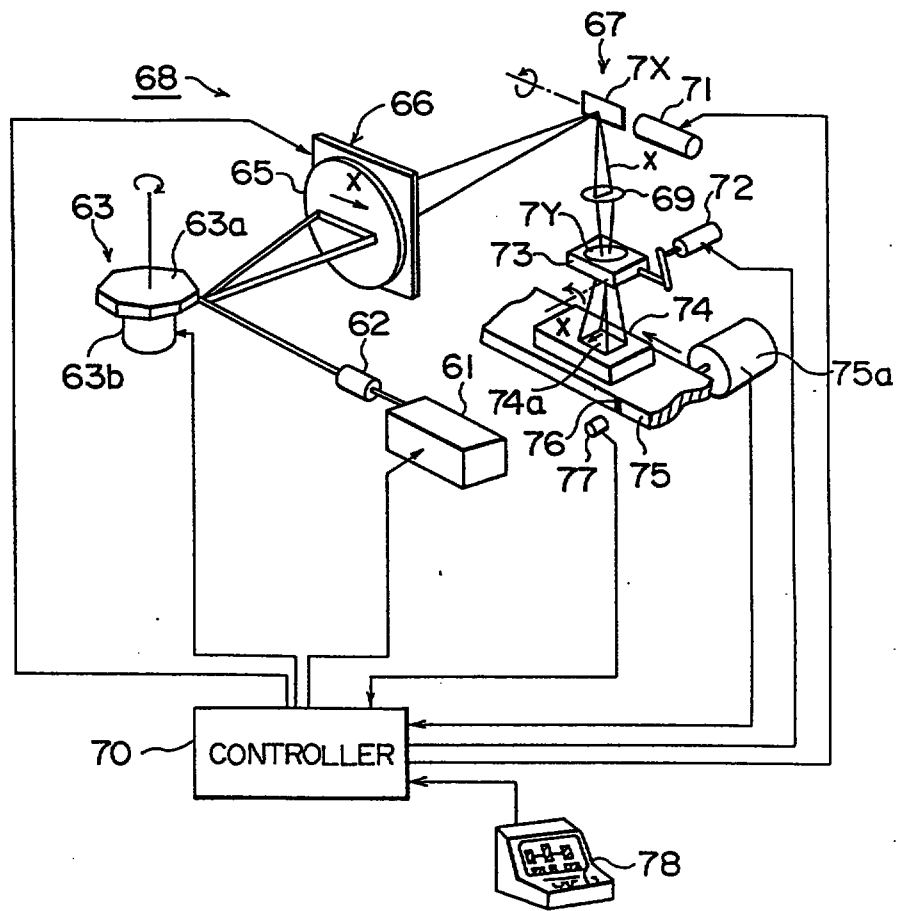


FIG. 13

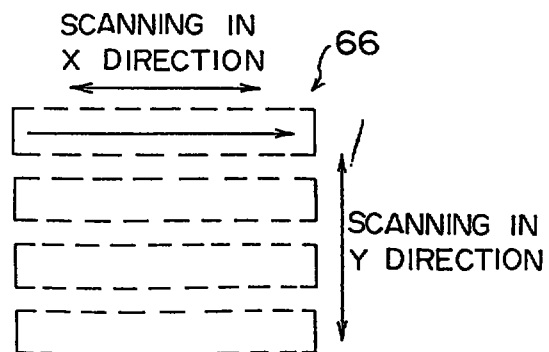


FIG. 14

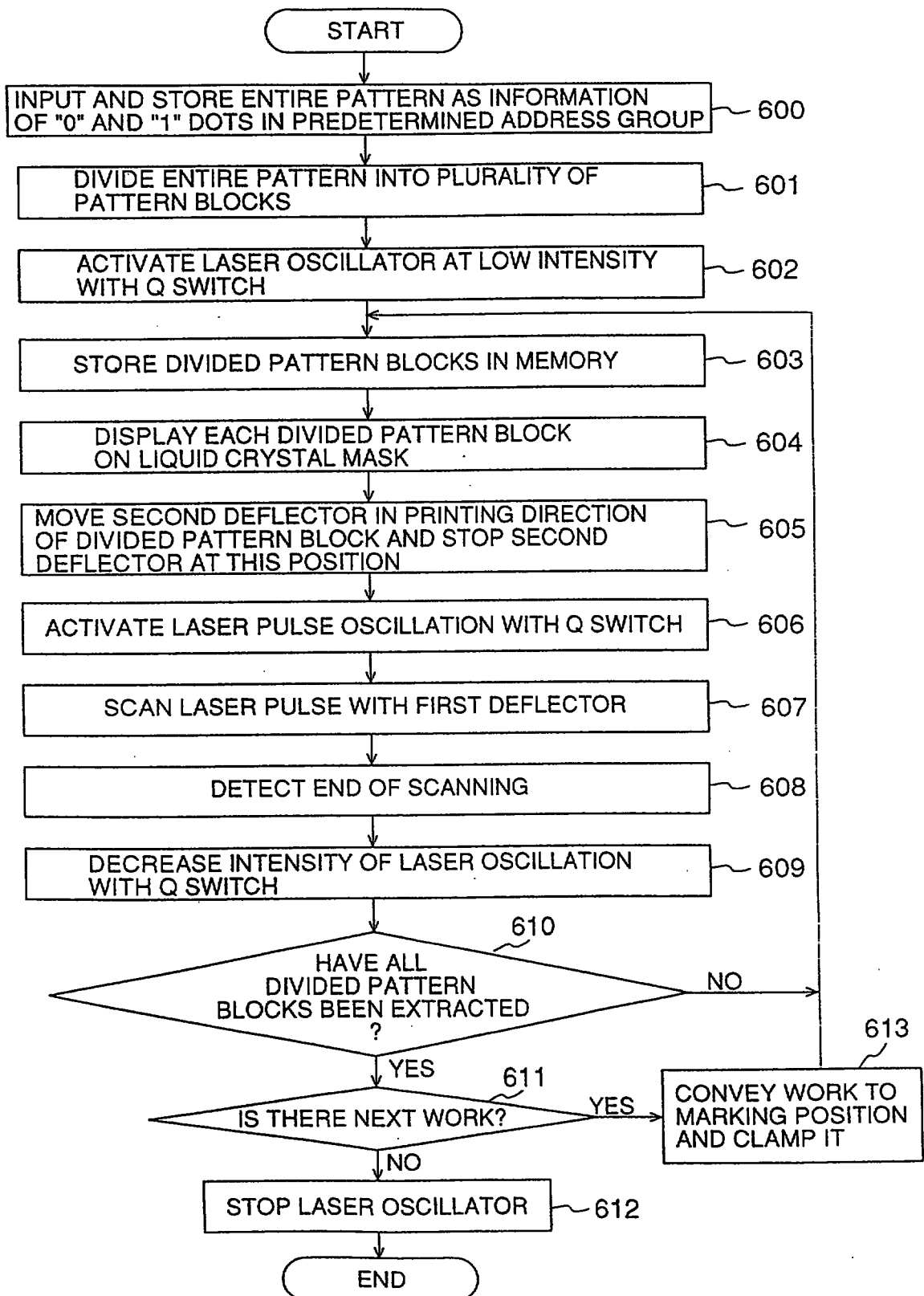


FIG.15

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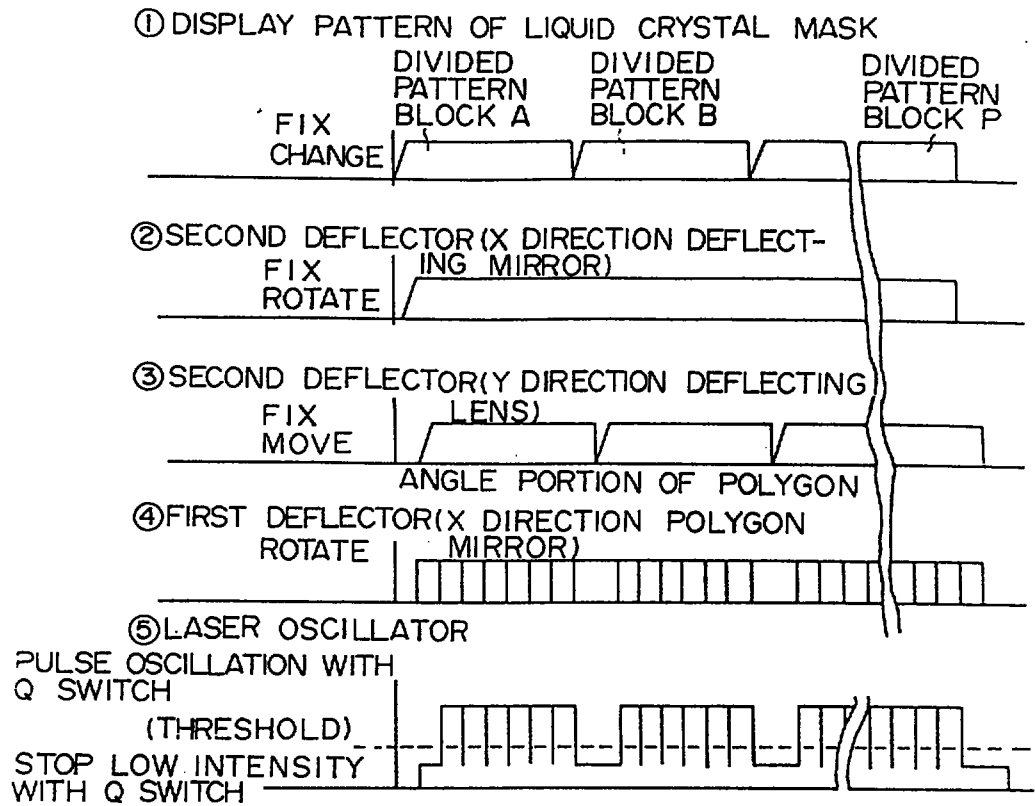


FIG. 16

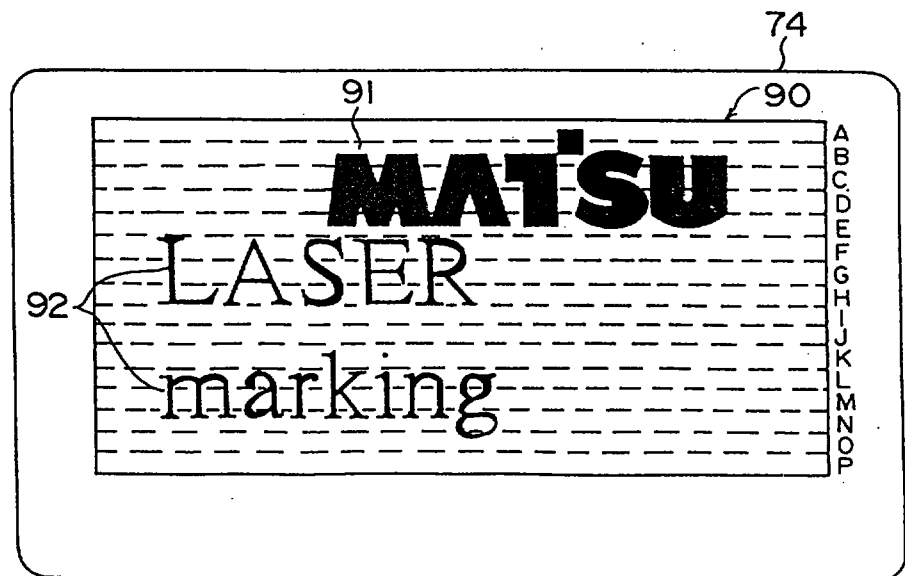


FIG. 17

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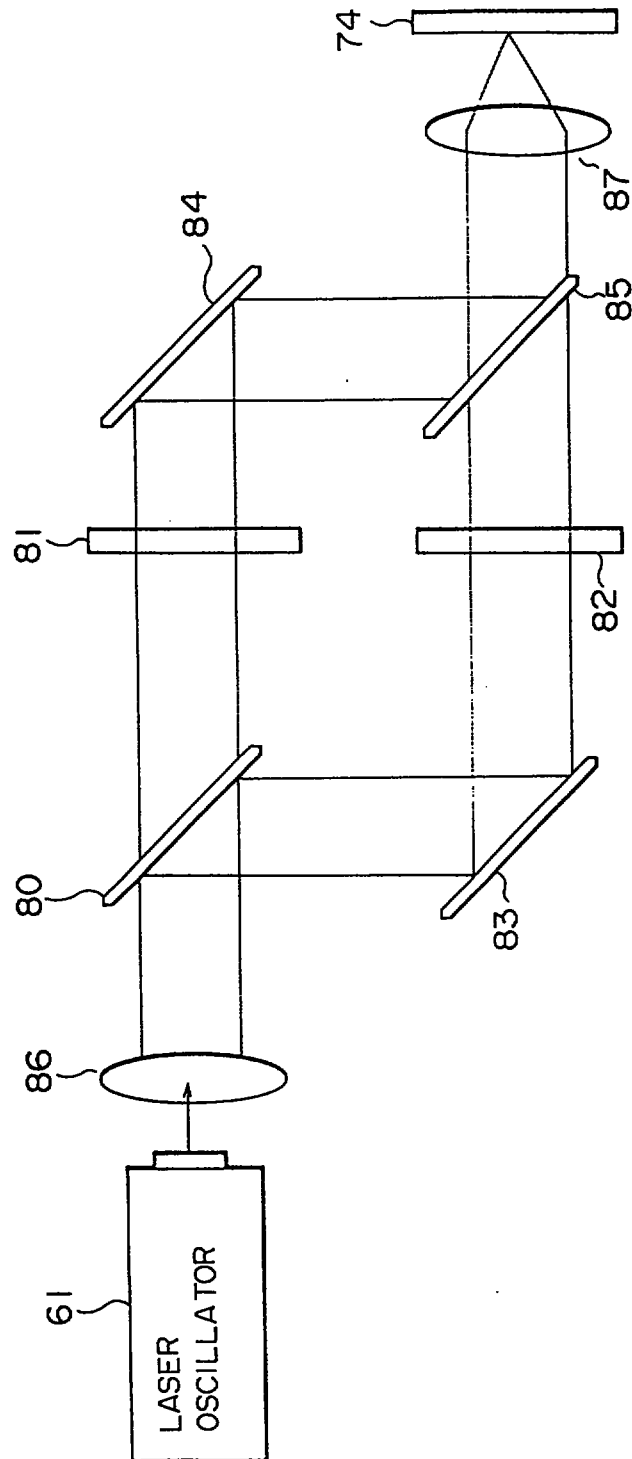


FIG. 18

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DISPLAY PATTERN ON FIRST
LIQUID CRYSTAL MASK

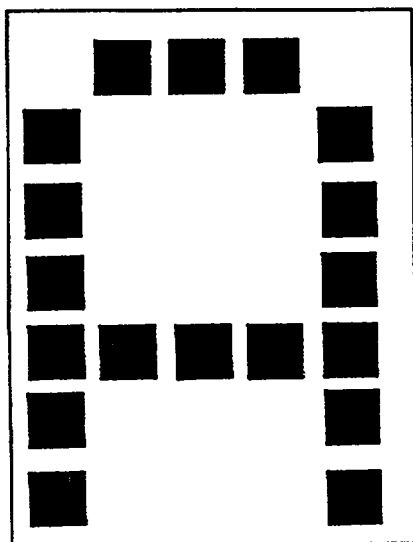


FIG. 19A

DISPLAY PATTERN ON SECOND
LIQUID CRYSTAL MASK

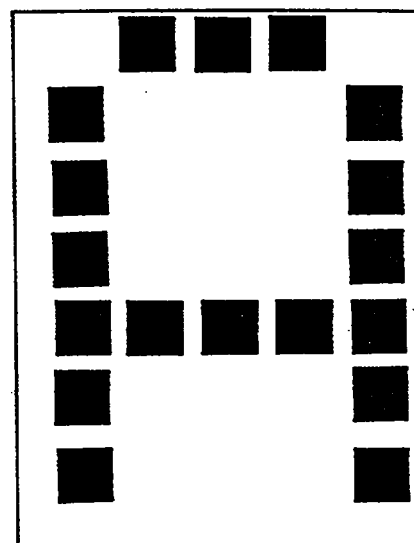


FIG. 19B

COMBINED DISPLAY PATTERN

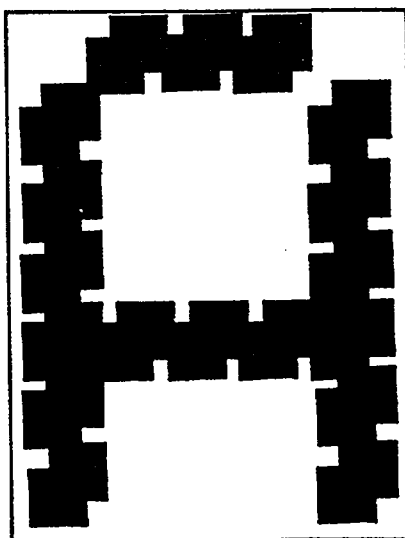


FIG. 19C



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REPLACEMENT SHEETS		30
☐ Description :	paged to paged	
☒ Claim(s) :	paged <u>30</u> to paged <u>30a</u>	
☐ Drawing(s) :	paged to paged	
☐ Abstract :	paged to paged	
DATE OF RECEIPT		28 MAY 1997

mask dots of a second mask image associated with a second optical path, and marking the recombined pattern on said workpiece.

10. A laser marking system for marking a workpiece, said system comprising:

a laser oscillator;

a mask;

a first deflector for scanning onto said mask, as only a single scanning line, a laser light generated by said laser oscillator;

said mask being adapted for displaying divided pattern blocks, each of said divided pattern blocks being equivalent to said single scanning line, wherein the divided pattern blocks constitute a marking pattern;

a second deflector for deflecting onto a surface of said workpiece a thus scanned laser light which has been selectively transmitted by said mask; and

control means, wherein said control means causes said mask to sequentially display the divided pattern blocks of the marking pattern, and wherein said control means causes said second deflector to deflect the thus scanned laser light for each divided pattern block to corresponding portions of the surface of said workpiece so as to mark on the surface of said workpiece a combined pattern as thus scanned by said first deflector and said second deflector.

11. A laser marking method for marking a surface of a workpiece, said method comprising the steps of:

generating a laser light beam;

scanning the thus generated laser light beam onto a mask as a single scanning line;

causing said mask to sequentially display a plurality of divided pattern blocks, with each of said divided pattern blocks being equivalent to a single scanning line, wherein the divided pattern blocks collectively constitute a marking pattern; and

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deflecting each thus scanned laser light beam, which corresponds to a respective divided pattern block and which has been selectively transmitted by said mask, onto a corresponding portion of the surface of said workpiece so as to mark on the surface of said workpiece a combination of said divided pattern blocks as said marking pattern.

12. A laser marking system substantially as described herein or with reference to the accompanying drawings.

13. A laser marking method, substantially as described herein.

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