

## Description

This invention relates to a light quantity control device adapted for use in a beam recording apparatus or the like.

In a known image recording apparatus, such as a laser beam printer, a semiconductor laser which emits a laser beam is used as a practical light source.

The semiconductor laser has a unique light quantity characteristic (I-I characteristic) between a laser driving current "I" and an emitted light quantity "I" as shown in Fig. 13. In Fig. 13, the vertical axis denotes the light quantity "I", and the horizontal axis denotes the laser driving current "I". The semiconductor laser does not emit the laser beam until the laser driving current "I" reaches a threshold value " $I_{th}$ ", but emits the laser beam when the laser driving current "I" exceeds the threshold value " $I_{th}$ " (such region is referred to generically as the "LED emitting region"). In the laser beam emitting region, the light quantity "I" has a certain slope " $\alpha$ " relative to the laser driving current "I".

In the known image recording apparatus, the laser is set to a non-emitting state (i.e., the laser output is set to zero) at first before initiating the printing of each page. The laser driving current " $I_T$ " is determined in such a way that a desirable prescribed light quantity " $I_T$ " can be obtained by monitoring the laser output and by controlling the laser driving current. The image recording apparatus holds the prescribed light quantity " $I_T$ " constant by performing constant-current driving of the laser driving current " $I_T$ " corresponding to the prescribed light quantity " $I_T$ ". However the I-I characteristic of the semiconductor laser, which has an initial form "A" as shown in Fig. 13, may vary to a form "B" or "C" due to variation in the chip temperature. Accordingly, in the laser beam printer, a constant-current driving circuit executes light quantity control (APC or auto power control) by clearing the laser output before initiating the printing of each page so as always to perform each printing operation with the desirable prescribed light quantity " $I_T$ ".

A method for deciding the current value of the constant-current driving circuit is proposed in U.S. Patent US-A-4,890,288 (corresponding to EP-A2-0258060 published before the present priority date), which method controls the current value by utilizing an IC (D/A converter) for converting a digital value into an analog value.

However, the conventional light quantity control device, which can control the light quantity characteristic to the driving current of the semiconductor laser by utilizing the D/A converter, suffers from the problem that the bit number of the D/A converter increases in the case where a precise light quantity control is required. That is, the conventional control device takes a lot of time to complete the light quantity control because of the large number of up-counting steps for

controlling the drive current increase in the case where the counting operation is initiated from a clear state.

It is an object of the present invention to provide an improved light quantity control device.

The invention provides a light quantity control device comprising: beam generating means; monitor means for monitoring the quantity of light of a beam generated by said beam generating means and providing an output; digital value output means for outputting a digital value in accordance with the output of said monitor means, and having first and second modes of operation for varying the digital values at high speed and low speed respectively; and supplying means for supplying a drive current corresponding to the digital value from said digital value output means to said beam generating means; characterised in that a finite response time must elapse before the effect of a change in the digital output value is reflected stably in the output of the monitor means, and in that the digital output value is changed at time intervals shorter than said response time in said first operating mode and not shorter than said response time in said second operating mode.

Other objects, features, and advantages of the invention will become apparent from the following detailed description of exemplary embodiments of the present invention and the accompanying drawings.

Fig. 1 is a block diagram showing an arrangement of a light quantity control device according to an embodiment of the present invention;

Fig. 2A is a chart for explaining output data from the laser light quantity comparator/controller shown in Fig. 1;

Fig. 2B is a chart showing the relation between the count value shown in Fig. A and the laser current;

Fig. 3 is a chart showing the relation between the monitor voltage output from the light quantity monitor circuit shown in Fig. 1 and the laser light quantity;

Fig. 4 is a chart for explaining a low-speed light quantity feedback control sequence of the light quantity control device;

Fig. 5 is a chart for explaining a high-speed light quantity feedback control sequence of the light quantity control device;

Fig. 6 is a flow chart for explaining an example of light quantity control procedure in the light quantity control device;

Fig. 7 is a illustration for explaining a light quantity adjusting timing of the light quantity control device;

Fig. 8 is a chart showing the relation between the monitor voltage of an initial APC processing and the count value;

Fig. 9 and Fig. 10 are charts showing the relation between the monitor voltage of an APC process-

ing after the initial APC processing and the count value;

Fig. 11 is a chart showing an APC processing of the light quantity control device according to a second embodiment of the present invention;

Fig. 12 is a chart showing an APC processing of a light quantity control device according to a third embodiment of the present invention; and

Fig. 13 is a chart showing a light quantity characteristic of a light source to which the light quantity control device is applied.

Three embodiments of the present invention will be described in detail herein with reference to the accompanying drawings.

#### Embodiment 1

Fig. 1 is a block diagram showing an arrangement of a light quantity control device according to the first embodiment of the present invention. The device shown in Fig. 1 includes an external controller 1, such as a personal computer, for controlling recording apparatus 3, such as a laser beam printer, by a standard interface (external interface) 4. Well known examples of the standard interface include RS232C, the Centronics interface, and GPIB (general purpose interface bus). The device also includes a controller 2 for converting data transmitted by the standard interface 4 into data for an internal interface 5 provided for the laser beam printer's exclusive use, and for controlling the recording apparatus 3 directly by means of the internal interface 5. The controller 2 may be mounted on an internal part of the recording apparatus 3 or the external controller 1, such as a personal computer, or disposed at an external part of the recording apparatus 3. A central processing unit (CPU) 6 is provided for performing the entire control of the recording apparatus, such as timing control of a motor mounted on the internal part of the recording apparatus 3 and temperature control of a fixing heater, which accompany information recording processing. A laser light quantity comparator/controller 7 composed of a one-chip microcomputer incorporating first and second analog-to-digital (A/D) converters is also provided. The CPU 6 and the laser light quantity comparator/controller 7 can be structured as a single CPU if the single CPU has a processing capacity which is able to control the control processing conditions properly. The A/D converters may be incorporated into the single CPU or disposed at an external part of the single CPU.

The device also includes a constant-current control circuit 8, which has a digital-to-analog (D/A) converter 8a connected to outputs Do-Dn of the laser light quantity comparator/controller 7, for converting the outputs Do-Dn (the outputs Do-Dn is used as a count control value) into an analog signal. In the case where the laser light quantity comparator/controller 7 is structured with a microcomputer incorporating a

D/A converter, the internal data bus of the microcomputer can constitute the outputs Do-Dn. A constant-current circuit 9 controlled by the constant-current control circuit 8 and receiving a laser current I1 through a switching circuit 10 is provided. A photodiode 12 is provided for receiving a laser beam emitted from a semiconductor laser 11 used as a light source. A light quantity monitor circuit 13 is provided for monitoring a detection signal supplied from the photodiode 12, and for outputting a light quantity monitor voltage  $V_M$  to the first A/D converter of the laser light quantity comparator/controller 7. A light quantity setting circuit 14 structured with a register is provided for outputting an output voltage  $V_O$  to the second A/D converter of the laser light quantity comparator/controller 7. The laser light quantity comparator/controller 7 makes and holds a comparison reference value internally by processing the output voltage  $V_O$  output from the light quantity setting circuit 14 internally. An OR gate 15 is provided for performing OR logic (gate) operation between a video signal VIDEO output through the internal interface 5 and a laser turning-on signal LON which overrides the data input and unconditionally turns on the semiconductor laser 11 to execute the light quantity control of the laser.

An operation of the light quantity control device in Fig. 1 will be described below.

When the photodiode 12 detects the light quantity of the laser beam emitted from the laser 11, the D/A converter 8a converts the count control value (outputs Do-Dn) output from the laser light quantity comparator/controller 7 into an analog signal based on the detected light quantity.

In these circumstances, the time required for each change of the count control value is controlled changeably by an output from a timing control means (the laser light quantity comparator/controller 7 operates as the timing control means in this case) based on the light quantity detected by the photodiode 12. Accordingly, it is possible to change the time for completing the light quantity control in dependence on the light quantity.

The timing control means executes a low-speed change processing for changing the count control value, which is output to the D/A converter 8a, after the lapse of a period, used for stabilizing the light quantity of the light beam detected by the photodiode 12, and enables the constant-current control circuit 8 to execute a constant-current control by giving priority to the stabilization of the light quantity.

The timing control means further executes a high-speed change processing for changing the count control value, which is output to the D/A converter 8a, before the lapse of the stabilization period for the light quantity of the light beam detected by the photodiode 12, and enables the constant-current control circuit 8 to execute a constant-current control by giving priority to the shortening of the time necessary

for light quantity control. The timing control means executes the low-speed change processing in the range of a reference light quantity value detected by the photodiode 12, and enables the control of the light quantity while maintaining the stability of the light quantity corresponding to image writing. The D/A converter 8a converts a count control value, which is obtained at the time an initial light quantity adjustment processing of the laser 11 is completed, sequentially, and outputs the converted count control value as an initial count control value for the next control to the constant-current control circuit 8. Therefore, it is possible to decrease the number of steps used for reaching a light quantity in a stable state, and to reach this light quantity in a short time.

An explanation of data output from the laser light quantity comparator/controller 7 will be described below with reference to Fig. 2A and Fig. 2B. Fig. 2A is an illustration for explaining data structures of outputs  $D_0$ - $D_n$  output from the laser light quantity comparator/controller 7 shown in Fig. 1. Fig. 2A shows the relation between an up-counting of the count value  $X_D$  and a down-counting of the count value  $X_D$ . As illustrated in Fig. 2A, the count value  $X_D$  input to the D/A converter 8a of the constant-current control circuit 8 is represented by an  $n+1$  bit binary number ( $D_n \times 2^n + D_{n-1} \times 2^{n-1} + \dots + D_3 \times 2^3 + D_2 \times 2^2 + D_1 \times 2 + D_0$ ) having the output  $D_n$  as the most significant bit (MSB). In Fig. 2A, "0" indicates a low (L) or false level, while "1" indicates a high (H) or true level.

Fig. 2B is a chart showing the relation between the count value  $X_D$  shown in Fig. 2A and the laser current  $I_L$ , wherein the vertical axis denotes the laser current  $I_L$ , and the horizontal axis denotes the count value  $X_D$ . As shown in Fig. 2B, it is assumed that the laser current  $I_L$  increases proportionally with the increase of the count value  $X_D$ .

Fig. 3 is a chart showing the relation between the monitor voltage  $V_M$  output from the light quantity monitor circuit 13 shown in Fig. 1 and the laser light quantity  $I_L$ , where the vertical axis denotes the monitor voltage  $V_M$ , and the horizontal axis denotes the laser light quantity  $I_L$ .

As shown in Fig. 3, the laser beam emitted from the semiconductor laser 11 is photoelectrically converted by the photodiode 12 in a laser unit 18, and is processed by the light quantity monitor circuit 13 to obtain the monitor voltage  $V_M$  corresponding to the laser light quantity  $I_L$  for feedback to the laser light quantity comparator/controller 7.

Explanations of a low-speed light quantity feedback control and a high-speed light quantity feedback control will be given below with reference to Fig. 4 and Fig. 5.

#### Low-speed Light Quantity-Feedback Control

Fig. 4 is a chart for explaining the low-speed light

quantity feedback control sequence of the light quantity control device. In Fig. 4, the same reference numerals are used to denote the corresponding elements explained in Fig. 2A, Fig. 2B, and Fig. 3.

In response to the up-counting of the count value  $X_D$  input to the D/A converter 8a, the laser current  $I_L$  increases, thereby increasing the monitor voltage  $V_M$ . As shown in Fig. 4, in response to the up-counting of the count value  $X_D$ , a certain time lag occurs until the monitor voltage  $V_M$  is stabilized. The time lag depends on a time constant or a response of the circuit.

Accordingly, in the case where the low-speed light quantity feedback control is executed, the count value  $X_D$  is incremented after the lapse of time  $T_2$ , after being held for a response time  $T_1$  ( $T_2 > T_1$ ).

According to the above-described structure, the light quantity can be stabilized although the stabilization of the light quantity control may take time.

For this reason, the present embodiment employs the low-speed or high-speed light quantity feedback control based on a difference between a predetermined voltage  $V_A$  and a difference voltage of the monitor voltage  $V_M$  and a prescribed light quantity voltage  $V_T$  provided for the laser 11. Thereby the light quantity control can be completed, at time  $T_3$ , at high speed while not affecting the stabilization of the light quantity.

#### High-speed Light Quantity Feedback Control

Fig. 5 is a chart for explaining the high-speed light quantity feedback control sequence of the light quantity control device. In Fig. 5, the same reference numerals are used to denote the corresponding elements explained in Fig. 2A, Fig. 2B, and Fig. 3. As shown in Fig. 5, in response to the up-counting of the count value  $X_D$  input to the D/A converter 8a, the control decides whether the count value  $X_D$  is counted up to its proper value or not at the lapse of time  $T_2$ , rather than the count value  $X_D$  being held for response time  $T_1$  ( $T_2 < T_1$ ), which is used for stabilizing the monitor voltage  $V_M$ . Thereby the upcounting processing of the count value  $X_D$  is executed at high speed, and the light quantity control can be completed, at time  $T_4$ , at high speed.

A light quantity control operation of the light quantity control device will be described below with reference to Fig. 6.

Fig. 6 is a flow chart for explaining an example of the light quantity control procedure in the light quantity control device. In Fig. 6, numerals (1)-(13) denote each step.

When a power source of the apparatus is turned on, the flow starts, and all information of the printer is cleared.

In step (1), a closed count value  $X_{D1}$  of the last automatic light quantity control is cleared (i.e.,  $X_{D1}=0$ ). In these circumstances, the laser light quan-

tity comparator/controller 7 stands by to wait for transmission (TRUE state) of an auto light quantity control start signal (APCST) sent from the CPU6 in step (2). When the auto light quantity control start signal (APCST) is transmitted, the laser light quantity comparator/controller 7 sets the count value  $X_D$  equal to the closed count value  $X_{D1}$  of the last automatic light quantity control in step (3). The count value  $X_D$  is used as a input signal to the D/A converter 8a of constant-current circuit 8. In the case where the first automatic light quantity control is performed after turning on the power source, the count value  $X_D$  is set at "0" because the closed count value  $X_{D1}$  is set at "0" in step (1). The auto light quantity control start signal (APCST) is output during an interval of each recording sheet P1-P3 in the case of consecutive printings shown in Fig. 7. The first auto light quantity control start signal (APCST) is output from the CPU6 just before the image writing to a recording sheet. In step (4), the laser light quantity comparator/controller 7 shifts the laser turning-on signal LON to a true level, to open the gate of the switching circuit 10, thereby supplying the semiconductor laser 11 with a laser current  $I_l$ . As explained above, the constant-current control circuit 8 having the D/A converter 8a is controlled by the up-counting or the down-counting of the digital value taken from the outputs  $D_0$ - $D_n$  from the laser light quantity comparator/controller 7, thereby varying the laser current  $I_l$  in the laser 11 by an analog value corresponding to the up-counting or the down-counting, through the constant-current circuit 9. In step (5), the laser light quantity comparator/controller 7 checks whether a condition  $|V_M - V_T| \leq V_a$  ( $|V_M - V_T|$  shows a difference between the prescribed light quantity voltage  $V_T$  corresponding to the prescribed light quantity  $I_T$  and the monitor voltage  $V_M$ ) is satisfied or not. If it is not, the above explained high-speed light quantity feedback control is executed in step (6). In steps (7), the count value is counted down, i.e., a formula  $X_D = X_D - 1$  is executed, if a condition  $V_M - V_T \geq 0$  is satisfied, but the count value is counted up, i.e., a formula  $X_D = X_D + 1$  is executed, if a condition  $V_M - V_T \leq 0$  is satisfied. Then the flow returns to step (5). In step (7), the step of the count value is not limited to "one"; rather the step of the count value can be set changeably, e.g., "2" or "3" or "n." It is also possible to change the number of steps for up-counting or down-counting in dependence on the monitor voltage  $V_M$ .

Meanwhile, when in step (5) the answer is yes, the low-speed light quantity feedback control is executed in step (8). In step (9), the laser light quantity comparator/controller 7 checks whether a condition  $|V_M - V_T| \leq V_b$  is satisfied or not. If it is not, the flow advances to step (10). In step (10), if a condition  $V_M - V_T \geq 0$  is satisfied, the count value is counted down, i.e., a formula  $X_D = X_D - 1$  is executed, but if a condition  $V_M - V_T < 0$  is satisfied, the count value is counted up,

i.e., a formula  $X_D = X_D + 1$  is executed. Then the flow returns to step (9). Meanwhile, if the answer in step (9) is yes, the present count value  $X_D$  is held in an internal memory of the CPU6 as a closed count value  $X_{D1}$  in step (11).

In step (12), laser light quantity comparator/controller 7 shifts the laser turning-on signal LON to a false level. Consequently, image recording can be performed by the video signal VIDEO sent from the controller 2. In step (13), the auto light quantity control is completed. Then the flow returns to step (2).

An explanation of a difference between an auto light quantity control performed at a time when the power source is turned on and an auto light quantity control performed at the next time will be described below with reference to Fig. 8-Fig. 10.

Fig. 8 is a chart showing the relation between the monitor voltage  $V_M$  of an initial APC processing and the count value  $X_D$ , wherein the horizontal axis denotes a time, the upper vertical axis denotes the monitor voltage  $V_M$ , and the lower vertical axis denotes the count value  $X_D$ .

As shown in Fig. 8, the count value  $X_D$  output from the laser light quantity comparator/controller 7 to the D/A converter 8a is increased sequentially from "0," and the semiconductor laser 11 starts to emit the laser beam when the count value  $X_D$  exceeds a count value corresponding to the threshold value  $I_{th}$  of the semiconductor laser 11, whereby the monitor voltage  $V_M$  is output. When the monitor voltage  $V_M$  is beyond a predetermined voltage ( $V_A$ ), that is, when the monitor voltage  $V_M$  is within a region A, the count value  $X_D$  output from the laser light quantity comparator/controller 7 to the D/A converter 8a is counted up at high speed. When the monitor voltage  $V_M$  is within the predetermined voltage ( $V_A$ ), i.e., a region B, by the up-counting of the count value  $X_D$ , the low-speed light quantity feedback control is executed. The APC processing is completed when the monitor voltage  $V_M$  reaches the prescribed light quantity voltage  $V_T$ .

Fig. 9 and Fig. 10 are charts showing the relation between the monitor voltage  $V_M$  of an APC processing after the initial APC processing and the count value  $X_D$ , wherein the horizontal axis denotes time, the upper vertical axis denotes the monitor voltage  $V_M$ , and the lower vertical axis denotes the count value  $X_D$ .

An explanation of the APC processing will be described below with reference to Fig. 6.

In the case where the count value  $X_D$  of the last automatic light quantity control is not set at "0," the closed count value  $X_{D1}$  should not be set at "0" in step (3). To put it concretely, the automatic light quantity control (APC) processing is started from a time when the auto light quantity control start signal (APCST) is shifted to a true level. In step (3), a count value set to the D/A converter 8a in the last automatic light quantity control, that is, the closed count value  $X_{D1}$ , is set as the count value  $X_D$ . In step (5), the monitor

voltage  $V_M$  should be a closed voltage of the last automatic light quantity control corresponding to the count value  $X_D$  at a time when the laser turning-on signal is shifted to a true level as shown in Fig. 9 or Fig. 10.

In step (5), the laser light quantity comparator/controller 7 checks the monitor voltage  $V_M$ . If the condition  $|V_M - V_T| \leq V_A$  is not satisfied, the flow advances to step (6), (7), and the high-speed light quantity feedback control is executed as described above.

Meanwhile, the condition  $|V_M - V_T| \leq V_A$  is often satisfied because the closed count value  $X_{D1}$  of the last automatic light quantity control is adopted. If the condition  $|V_M - V_T| \leq V_A$  is satisfied, the low-speed light quantity feedback control is executed in step (8).

In step (9), the laser light quantity comparator/controller 7 checks whether the condition  $|V_M - V_T| \leq V_A$  is satisfied or not.

If it is not, the flow advances to step (10). In step (10), the up-counting (see Fig. 9) or the down-counting (see Fig. 10) of the count value  $X_D$  is executed, and thereby an appropriate count value  $X_D$  is set by a fewer number of steps.

According to the above-described structure, a control time for reaching the prescribed light quantity voltage  $V_T$ , i.e., a time from the initiation of the APC processing to the completion of the APC processing, can be shortened sharply.

In the above-described embodiment, the up-counting or the down-counting of the count value  $X_D$  is performed under the condition that a time for changing the count value is constant. However, in the case where a response of the circuit to the change operation of the count value  $X_D$  or a sampling time of the CPU6 is slow, the count value  $X_D$  should be held every predetermined number of up-counting or down-counting as shown in Fig. 9 or Fig. 10. Thereby the count value  $X_D$  can be counted up or counted down in a state that the monitor voltage  $V_M$  is stabilized.

#### Embodiment 2

Fig. 11 is a chart showing an APC processing of the light quantity control device according to a second embodiment of the present invention. In Fig. 11, the same reference numerals are used to denote the corresponding elements shown in Fig. 10.

As shown in Fig. 11, when the power source of the apparatus is turned on, the count value  $X_D$  received by the D/A converter 8a starts from "0," i.e., a count value  $X_{D(0)}$ . When the count value  $X_D$  coincides with a count value  $X_{D(th)}$ , the laser current  $I_L$  exceeds a threshold value current  $I_{th}$  of the semiconductor laser 11, so that the semiconductor laser 11 starts to emit the laser beam.

In the case where a response of the circuit to the change operation of the count value  $X_D$  or a sampling

time of the CPU6 is slow, a predetermined number of up-counting steps are executed to obtain a count value  $X_{D(A)}$ , and the count value  $X_{D(A)}$  is held until the monitor voltage  $V_M$  corresponding to the count value  $X_{D(A)}$  is stabilized. After the stabilization of the monitor voltage  $V_M$ , the up-counting of the count value  $X_D$  is restarted to execute a predetermined number of up-counting steps for obtaining a count value  $X_{D(B)}$ . After the predetermined number of up-counting steps are executed, the count value  $X_{D(B)}$  is held for stabilizing the monitor voltage  $V_M$ . When the stabilized monitor voltage  $V_M$  corresponding to the count value  $X_{D(B)}$  is within a predetermined range, that is, when the condition  $|V_M - V_T| \leq V_A$  is satisfied, the above-described low-speed light quantity control is executed, thereby the light quantity is controlled to comply with the prescribed light quantity voltage  $V_T$ .

In the above-described embodiment, the light quantity control is carried out by using a count value having a constant step. However, it is possible to shorten the time of the light quantity control by combining such processing where the step for counting is large in the initial control, and the step gets smaller when the light quantity exceeds a predetermined level as shown in U.S. Patent No. 4,890,288 (see Fig. 15).

#### Embodiment 3

Fig. 12 is a chart for showing an APC processing of the light quantity control device according to a third embodiment of the present invention. In Fig. 12, the same reference numerals are used to denote the corresponding elements shown in Fig. 10.

As shown in Fig. 12, predetermined voltages  $V_A$ ,  $V_B$ ,  $V_C$  are provided as critical voltages. The high-speed count is increased by 3 counts at a time when the monitor voltage  $V_M$  is lower than the predetermined voltage  $V_C$ . The high-speed count is increased by 2 counts at a time when the monitor voltage  $V_M$  exceeds the predetermined voltage  $V_C$ . Then, the high-speed count is increased by 1 count at a time when the monitor voltage  $V_M$  exceeds the predetermined voltage  $V_B$ . The high-speed count, i.e., the high-speed light quantity feedback control, should be changed over to the low-speed light quantity feedback control when the monitor voltage  $V_M$  exceeds the predetermined voltage  $V_A$ .

According to the above-described structure, a time of the light quantity control can be shortened sharply.

As mentioned above, according to the present invention, high-speed and high-precision light quantity control can be provided.

Although particular embodiments of the present invention are herein disclosed for purposes of explanation, various modifications thereof, after study of this specification, will be apparent to those skilled in

the art to which the invention pertains.

In this application, the word "light" will be understood not to be limited to the visible radiation spectrum but to encompass the infra-red region and any other such region of the electromagnetic spectrum as may from time to time be useful in a beam recording apparatus or the like; the wavelength of emission of a beam producing device is readily selectable by the skilled man.

## Claims

1. A light quantity control device comprising:  
beam generating means (11);  
monitor means (12, 13) for monitoring the quantity of light of a beam generated by said beam generating means and providing an output;  
digital value output means (7) for outputting a digital value in accordance with the output of said monitor means, and having first and second modes of operation for varying the digital values at high speed and low speed respectively; and  
supplying means (8a, 8, 9) for supplying a drive current corresponding to the digital value from said digital value output means to said beam generating means;  
characterised in that a finite response time (T1) must elapse before the effect of a change in the digital output value is reflected stably in the output of the monitor means, and in that the digital output value is changed at time intervals shorter than said response time in said first operating mode and not shorter than said response time in said second operating mode.
2. A light quantity control device according to claim 1, wherein said beam generating means comprises a semiconductor laser.
3. A light quantity control device according to claim 1 or 2, wherein said monitor means detects the quantity of light of the beam as a monitor voltage.
4. A light quantity control device according to claim 1, 2 or 3, wherein said supplying means comprises digital-to-analog converter means (8a) for effecting digital-to-analog conversion of the digital value supplied from said digital value output means and producing an output; driving current control circuit (8) for controlling a drive current for said beam generating means in response to the output of said digital-to-analog converter; and drive current generating means (9) for generating the drive current.
5. A light quantity control device according to any

preceding claim, wherein said digital value output means operates in the first mode when the output of said monitor means is in a first range, and operates in the second mode when the output of said monitor means is in a second range different from the first range.

6. A light quantity control device according to any preceding claim, further comprising setting means (14) for setting the value representing the quantity of light of the beam to be generated from said beam generating means.
7. A light quantity control device according to claim 6, wherein said digital value output means compares the output from said monitoring means with the value set by said setting means, and varies the digital value output in accordance with the comparison.
8. A light quantity control device according to any preceding claim, wherein said digital value output means includes an A/D converter for converting the output from said monitor means into a digital value.
9. A light quantity control device according to claim 8, wherein said digital value output means is a micro-computer incorporating the A/D converter.
10. A light quantity control device according to any preceding claim, wherein said digital value output means discriminates whether the output of said monitor means reaches a predetermined level and wherein said digital value output means operates in the first mode when the output of said monitor means is discriminated to be lower than the predetermined level, and operates in the second mode when the output of said monitor means is discriminated to reach the predetermined level.
11. A light quantity control device according to claim 10, wherein said digital value output means is capable of varying the amount of each change of the digital value in accordance with the output of said monitor means when the output of said monitor means is discriminated to be in a predetermined range lower than the predetermined level.
12. A light quantity control device according to claim 10 or 11, further comprising setting means (14) for setting a value representing the quantity of light of the beam to be generated, for comparison with the output of said monitor means, wherein said predetermined level is defined relative to said set value.
13. An image recording apparatus including a light



the art to which the invention pertains.

In this application, the word "light" will be understood not to be limited to the visible radiation spectrum but to encompass the infra-red region and any other such region of the electromagnetic spectrum as may from time to time be useful in a beam recording apparatus or the like; the wavelength of emission of a beam producing device is readily selectable by the skilled man.

### Claims

**1. A light quantity control device comprising:**

beam generating means (11);

monitor means (12, 13) for monitoring the quantity of light of a beam generated by said beam generating means and providing an output;

digital value output means (7) for outputting a digital value in accordance with the output of said monitor means, and having first and second modes of operation for varying the digital values at high speed and low speed respectively; and

supplying means (8a, 8, 9) for supplying a drive current corresponding to the digital value from said digital value output means to said beam generating means;

characterised in that a finite response time (T1) must elapse before the effect of a change in the digital output value is reflected stably in the output of the monitor means, and in that the digital output value is changed at time intervals shorter than said response time in said first operating mode and not shorter than said response time in said second operating mode.

**2. A light quantity control device according to claim 1, wherein said beam generating means comprises a semiconductor laser.**

**3. A light quantity control device according to claim 1 or 2, wherein said monitor means detects the quantity of light of the beam as a monitor voltage.**

**4. A light quantity control device according to claim 1, 2 or 3, wherein said supplying means comprises digital-to-analog converter means (8a) for effecting digital-to-analog conversion of the digital value supplied from said digital value output means and producing an output; driving current control circuit (8) for controlling a drive current for said beam generating means in response to the output of said digital-to-analog converter; and drive current generating means (9) for generating the drive current.**

**5. A light quantity control device according to any**

preceding claim, wherein said digital value output means operates in the first mode when the output of said monitor means is in a first range, and operates in the second mode when the output of said monitor means is in a second range different from the first range.

**6. A light quantity control device according to any preceding claim, further comprising setting means (14) for setting the value representing the quantity of light of the beam to be generated from said beam generating means.**

**7. A light quantity control device according to claim 6, wherein said digital value output means compares the output from said monitoring means with the value set by said setting means, and varies the digital value output in accordance with the comparison.**

**8. A light quantity control device according to any preceding claim, wherein said digital value output means includes an A/D converter for converting the output from said monitor means into a digital value.**

**9. A light quantity control device according to claim 8, wherein said digital value output means is a micro-computer incorporating the A/D converter.**

**10. A light quantity control device according to any preceding claim, wherein said digital value output means discriminates whether the output of said monitor means reaches a predetermined level and wherein said digital value output means operates in the first mode when the output of said monitor means is discriminated to be lower than the predetermined level, and operates in the second mode when the output of said monitor means is discriminated to reach the predetermined level.**

**11. A light quantity control device according to claim 10, wherein said digital value output means is capable of varying the amount of each change of the digital value in accordance with the output of said monitor means when the output of said monitor means is discriminated to be in a predetermined range lower than the predetermined level.**

**12. A light quantity control device according to claim 10 or 11, further comprising setting means (14) for setting a value representing the quantity of light of the beam to be generated, for comparison with the output of said monitor means, wherein said predetermined level is defined relative to said set value.**

**13. An image recording apparatus including a light**



quantity control device according to any preceding claim.

14. An image recording apparatus according to claim 13, further comprising means for initiating a light quantity control operation of the light quantity control device just before a first image is written to a first recording sheet, and in intervals between the writing of subsequent images on consecutive recording sheets.

#### Patentansprüche

1. Lichtmengensteuerungsvorrichtung enthaltend:  
eine Strahlerzeugungsvorrichtung (11);  
eine Überwachungsvorrichtung (12, 13)  
zum Überwachen der Lichtmenge eines durch die Strahlerzeugungsvorrichtung erzeugten Strahls und zum Liefern eines Ausgangs;  
eine Digitalwertausgabevorrichtung (7)  
zum Ausgeben eines Digitalwertes in Übereinstimmung mit dem Ausgang der Überwachungsvorrichtung, mit ersten und zweiten Betriebsarten zum Variieren der Digitalwerte mit hoher bzw. niedriger Geschwindigkeit; und  
eine Zuführvorrichtung (8a, 8, 9) zum Zuführen eines dem Digitalwert von der Digitalwertausgabevorrichtung entsprechenden Ansteuerstromes an die Strahlerzeugungsvorrichtung;  
dadurch gekennzeichnet, daß eine begrenzte Antwortzeit (T1) vergehen muß, bevor der Effekt einer Änderung im digitalen Ausgabewert sich im Ausgang der Überwachungsvorrichtung stabil widerspiegelt, und daß der digitale Ausgabewert in Zeitintervallen geändert wird, die in der ersten Betriebsart kürzer sind als die Antwortzeit und in der zweiten Betriebsart nicht kürzer sind als die Antwortzeit.
2. Lichtmengensteuerungsvorrichtung nach Anspruch 1, wobei die Strahlerzeugungsvorrichtung einen Halbleiterlaser aufweist.
3. Lichtmengensteuerungsvorrichtung nach Anspruch 1 oder 2, wobei die Überwachungsvorrichtung die Lichtmenge des Strahls als eine Überwachungsspannung erfaßt.
4. Lichtmengensteuerungsvorrichtung nach Anspruch 1, 2 oder 3, wobei die Zuführvorrichtung eine Digital/Analog-Wandlernvorrichtung (8a) zum Ausführen einer Digital/Analog-Wandlung des von der Digitalwertausgabevorrichtung zugeführten Digitalwertes und zum Erzeugen eines Ausgangs, eine Ansteuerstromsteuerungsschaltung (8) zur Steuerung eines Ansteuerstromes für die Strahlerzeugungsvorrichtung im Anspre-

chen auf den Ausgang des Digital/Analog-Wandlers, und eine Ansteuerstromerzeugungsvorrichtung (9) zum Erzeugen des Ansteuerstromes aufweist.

5. Lichtmengensteuerungsvorrichtung nach einem der vorhergehenden Ansprüche, wobei die Digitalwertausgabevorrichtung in der ersten Betriebsart arbeitet, wenn der Ausgang der Überwachungsvorrichtung in einem ersten Bereich liegt, und in der zweiten Betriebsart arbeitet, wenn der Ausgang der Überwachungsvorrichtung in einem vom ersten Bereich verschiedenen zweiten Bereich liegt.
6. Lichtmengensteuerungsvorrichtung nach einem der vorhergehenden Ansprüche, ferner aufweisend eine Setzeinrichtung (14) zum Setzen des Wertes, der die Lichtmenge des von der Strahlerzeugungsvorrichtung zu erzeugenden Strahls repräsentiert.
7. Lichtmengensteuerungsvorrichtung nach Anspruch 6, wobei die Digitalwertausgabevorrichtung den Ausgang von der Überwachungsvorrichtung mit dem durch die Setzeinrichtung gesetzten Wert vergleicht und den digitalen Ausgabewert entsprechend dem Vergleich variiert.
8. Lichtmengensteuerungsvorrichtung nach einem der vorhergehenden Ansprüche, wobei die Digitalwertausgabevorrichtung einen A/D-Wandler zum Umwandeln des Ausgangs von der Überwachungsvorrichtung in einen digitalen Wert enthält.
9. Lichtmengensteuerungsvorrichtung nach Anspruch 8, wobei die Digitalwertausgabevorrichtung ein den A/D-Wandler enthaltender Mikrocomputer ist.
10. Lichtmengensteuerungsvorrichtung nach einem der vorhergehenden Ansprüche, wobei die Digitalwertausgabevorrichtung entscheidet, ob der Ausgang der Überwachungsvorrichtung einen vorbestimmten Pegel erreicht und wobei die Digitalwertausgabevorrichtung in der ersten Betriebsart arbeitet, wenn entschieden wird, daß der Ausgang der Überwachungsvorrichtung niedriger als der vorbestimmte Pegel ist, und in der zweiten Betriebsart arbeitet, wenn entschieden wird, daß der Ausgang der Überwachungsvorrichtung den vorbestimmten Pegel erreicht.
11. Lichtmengensteuerungsvorrichtung nach Anspruch 10, wobei die Digitalwertausgabevorrichtung in der Lage ist, den Umfang jeder Änderung des Digitalwertes entsprechend dem Ausgang



der Überwachungsvorrichtung zu variieren, wenn entschieden wird, daß der Ausgang der Überwachungsvorrichtung in einem vorbestimmten Bereich unter dem vorbestimmten Pegel liegt.

12. Lichtmengensteuerungsvorrichtung nach Anspruch 10 oder 11, ferner aufweisend eine Setzvorrichtung (14) zum Setzen eines die Lichtmenge des zu erzeugenden Strahls repräsentierenden Wertes für den Vergleich mit dem Ausgang mit der Überwachungsvorrichtung, wobei der vorbestimmte Pegel relativ zum Setzwert definiert wird.

13. Bildaufzeichnungsgerät enthaltend die Lichtmengensteuerungsvorrichtung nach einem der vorhergehenden Ansprüche.

14. Bildaufzeichnungsgerät nach Anspruch 13, ferner aufweisend eine Vorrichtung zum Einleiten eines Lichtmengensteuerungsvorganges der Lichtmengensteuerungsvorrichtung unmittelbar bevor ein erstes Bild auf ein erstes Aufzeichnungsblatt geschrieben wird, und in Intervallen zwischen dem Schreiben aufeinanderfolgender Bilder auf aufeinanderfolgende Aufzeichnungsblätter.

#### Revendications

1. Dispositif de commande d'une quantité de lumière comprenant:  
des moyens (11) de génération de faisceau;  
des moyens de contrôle (12, 13) pour contrôler la quantité de lumière d'un faisceau généré par lesdits moyens de génération de faisceau, et délivrant une sortie;  
des moyens (7) de sortie de valeurs numériques pour délivrer une valeur numérique en fonction de la sortie desdits moyens de contrôle, et ayant des premier et second modes de fonctionnement pour faire varier les valeurs numériques à vitesse élevée et à vitesse faible, respectivement; et  
des moyens d'alimentation (8a, 8, 9) pour appliquer un courant de commande, correspondant à la valeur numérique en provenance desdits moyens de sortie de valeurs numériques, auxdits moyens de génération de faisceau;  
caractérisé en ce qu'un temps de réponse fini (T1) doit s'écouler avant que l'effet d'une variation de la valeur numérique de sortie soit reflété d'une manière stable à la sortie des moyens de contrôle, et en ce que la valeur numérique de sortie est modifiée à des intervalles de temps plus courts que ledit temps de réponse dans ledit pre-

mier mode de fonctionnement et pas plus courts que ledit temps de réponse dans ledit second mode de fonctionnement.

2. Dispositif de commande d'une quantité de lumière selon la revendication 1, dans lequel lesdits moyens de génération de faisceau comprennent un laser à semiconducteur.

3. Dispositif de commande d'une quantité de lumière selon la revendication 1 ou 2, dans lequel lesdits moyens de contrôle détectent la quantité de lumière du faisceau sous la forme d'une tension de contrôle.

4. Dispositif de commande d'une quantité de lumière selon la revendication 1, 2 ou 3, dans lequel lesdits moyens d'alimentation comprennent un moyen (80a) formant convertisseur numérique-analogique pour effectuer une conversion numérique-analogique de la valeur numérique en provenance desdits moyens de sortie de valeurs numériques et produisant une sortie; un circuit de commande (8) du courant de commande pour commander un courant de commande destiné auxdits moyens de génération de faisceau en réponse à la sortie dudit convertisseur numérique-analogique; et un moyen (9) générateur de courant de commande pour générer le courant de commande.

5. Dispositif de commande d'une quantité de lumière selon l'une quelconque des revendications précédentes, dans lequel lesdits moyens de sortie de valeurs numériques fonctionnent dans le premier mode lorsque la sortie desdits moyens de contrôle est dans une première plage, et fonctionnent dans le second mode lorsque la sortie desdits moyens de contrôle est dans une seconde plage, différente de la première plage.

6. Dispositif de commande d'une quantité de lumière selon l'une quelconque des revendications précédentes, comprenant en outre des moyens de réglage (14) pour régler la valeur représentant la quantité de lumière du faisceau à générer par lesdits moyens de génération de faisceau.

7. Dispositif de commande d'une quantité de lumière selon la revendication 6, dans lequel lesdits moyens de sortie de valeurs numériques comparent la sortie desdits moyens de contrôle avec la valeur réglée par lesdits moyens de réglage, et font varier la valeur numérique de sortie en fonction de la comparaison.

8. Dispositif de commande d'une quantité de lumière selon l'une quelconque des revendications



précédentes, dans lequel lesdits moyens de sortie de valeurs numériques comportent un convertisseur A/N pour convertir la sortie desdits moyens de contrôle en une valeur numérique.

d'enregistrement consécutives.

9. Dispositif de commande d'une quantité de lumière selon la revendication 8, dans lequel lesdits moyens de sortie de valeurs numériques sont constitués par un micro-ordinateur incorporant le convertisseur A/N.

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10. Dispositif de commande d'une quantité de lumière selon l'une quelconque des revendications précédentes, dans lequel lesdits moyens de sortie de valeurs numériques effectuent une discrimination pour voir si la sortie desdits moyens de contrôle atteint un niveau prédéterminé et dans lequel lesdits moyens de sortie de valeurs numériques fonctionnent dans le premier mode lorsque la sortie desdits moyens de contrôle est discriminée comme étant inférieure au niveau prédéterminé, et fonctionnent dans le second mode lorsque la sortie desdits moyens de contrôle est discriminée comme atteignant le niveau prédéterminé.

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11. Dispositif de commande d'une quantité de lumière selon la revendication 10, dans lequel lesdits moyens de sortie de valeurs numériques peuvent faire varier la grandeur de chaque changement de la valeur numérique en fonction de la sortie desdits moyens de contrôle lorsque la sortie desdits moyens de contrôle est discriminée comme étant dans une plage prédéterminée inférieure au niveau prédéterminé.

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12. Dispositif de commande d'une quantité de lumière selon la revendication 10 ou 11, comprenant en outre un moyen de réglage (14) pour régler une valeur représentant la quantité de lumière du faisceau à générer, pour la comparaison avec la sortie desdits moyens de contrôle, dans lequel ledit niveau prédéterminé est défini par rapport à ladite valeur réglée.

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13. Appareil d'enregistrement d'images comportant un dispositif de commande d'une quantité de lumière selon l'une quelconque des revendications précédentes.

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14. Appareil d'enregistrement d'images selon la revendication 13, comportant en outre un moyen pour amorcer l'opération de commande de quantité de lumière du dispositif de commande de quantité de lumière juste avant qu'une première image soit écrite sur une première feuille d'enregistrement, et dans les intervalles compris entre les écritures d'images suivantes sur des feuilles

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