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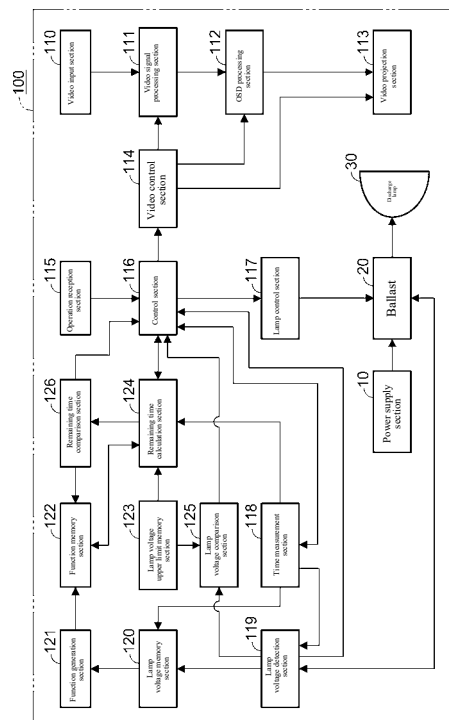
(54)[Title of invention] Display device

(57) [Summary]

[Issues] The objective is to provide a display device that can take into account the characteristics of the discharge lamp and calculate the appropriate remaining time until the end-of-life of the discharge lamp.

[Means for solving] A time measurement section 118 that measures the time of use from the start of use of the discharge lamp 30, a lamp voltage upper limit memory section 123 that stores the lamp voltage upper limit, which is the lamp voltage upper limit at which the discharge lamp is operable, a function memory section 122 that stores the lamp voltage function that predicts changes over the course of the lamp voltage, and a residual time calculation section 124 that calculates the difference between the first time derived from the lamp voltage upper limit and the lamp voltage function and the usage time measured by the time measurement section as the remaining time of use of the discharge lamp.

[Selected Drawing] FIG. 3



[Scope of Claims]

[Claim 1]

A display device equipped with a discharge lamp, characterized by comprising:
 a time measurement section that measures the usage time of the discharge lamp from the start of use;
 a lamp voltage upper limit memory section that stores a lamp voltage upper limit value that is the upper limit lamp voltage at which the discharge lamp can operate;
 a function memory section that stores a lamp voltage function that predicts the change in the lamp voltage over the usage time;
 and a remaining time calculation section that calculates the difference between a first time derived from the lamp voltage upper limit value and the lamp voltage function and the usage time measured by the time measurement section as the remaining usable time of the discharge lamp.

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[Claim 2]

The display device according to Claim 1,
 characterized by further comprising:
 a lamp voltage detection section that detects the lamp voltage when the discharge lamp is driven;
 a lamp voltage memory section that stores the lamp voltage detected by the lamp voltage detection section and the usage time at the time of detection;
 and a function generation section that generates the lamp voltage function based on the lamp voltage and the usage time stored in the lamp voltage memory section.

[Claim 3]

The display device according to Claim 2,
 characterized in that the lamp voltage detection section detects the lamp voltage at each predetermined usage time interval,
 the lamp voltage memory section stores the lamp voltage and the usage time at the time of detection at each predetermined usage time interval,
 and the function generation section generates the lamp voltage function based on the lamp voltage and the usage time stored in the lamp voltage memory section at each predetermined usage time interval.

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[Claim 4]

The display device according to Claim 3,
 characterized in that the function generation section stops generating the lamp voltage function when the remaining time calculated by the remaining time calculation section becomes equal to or less than a predetermined first remaining time.

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[Claim 5]

The display device according to any one of Claims 1 to 4,
 characterized by having a first display section that displays the remaining time calculated by the remaining time calculation section.

[Claim 6]

The display device according to any one of Claims 1 to 5,
 characterized by having a second display section that displays a message urging the user to replace the discharge lamp when the remaining time calculated by the remaining time calculation section is equal to or less than a predetermined second remaining time.

[Claim 7]

The display device according to any one of Claims 1 to 6,
 characterized in that the display device turns off the discharge lamp when the remaining time calculated by the remaining time calculation section is equal to or less than 0.

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[Claim 8]

The display device according to any one of Claims 2 to 7,
 characterized in that the discharge lamp is configured as a lamp unit,
 the lamp section includes a lamp information memory section,
 and the lamp information memory section includes the lamp voltage memory section and the function memory section.

[Detailed Description of the Invention]

[Technical field]

[0001]

The present invention relates to a display device that projects video using a discharge lamp.

[Prior Art]

[0002]

Conventionally, it is known that a projection type display device detects a terminal voltage (lamp voltage) each time a lighting lamp (discharge lamp) is turned on, determines the difference between the terminal voltage detected at the time of the previous lighting recorded in the memory, and determines that the end-of-life of the lighting lamp is near when the increase in terminal voltage is less than a predetermined value (Patent Literature 1). However, Patent Literature 1 does not consider detecting the remaining time to the end-of-life of the lighting lamp.

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[0003]

On the other hand, a technology is disclosed to calculate the remaining time to the end-of-life of the light source lamp (discharge lamp). For example, a projector has been proposed to store the scheduled replacement time of the light source lamp, measure the cumulative usage time of the light source lamp, and subtract the cumulative usage time from the scheduled replacement time to obtain the remaining time for the scheduled replacement time, and display information indicating the replacement time of the light source lamp (Patent Literature 2).

[0004]

[Patent Literature 1] Japanese Unexamined Patent Application Publication 2002-122940

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[Patent Literature 2] Japanese Unexamined Patent Application Publication 2002-287243

[Disclosure of invention]

[Problem to be Solved by the Invention]

[0005]

Discharge lamps are known to wear electrodes due to long-term lighting, and wear increases the distance between electrodes, resulting in an increase in lamp voltage. Then, when the lamp voltage reaches the predetermined value specified as the specification of the discharge lamp, it is determined to be the end-of-life of the discharge lamp, and the use of the discharge lamp is discontinued to ensure safety. However, the characteristics of the lamp voltage increase and change over time vary depending on the type of discharge lamp and the individual difference, and the remaining time to end-of-life is greatly affected by the characteristics of this lamp voltage. Therefore, the technology described in Patent Literature 2 did not take into account the characteristics of such discharge lamps, so there was a problem in terms of calculating the appropriate remaining time.

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[0006]

The present invention is made to solve such a problem and is intended to provide a display device that can take into account the characteristics of the discharge lamp and calculate the appropriate remaining time until the end-of-life of the discharge lamp.

[Means for solving the problem]

[0007]

In order to achieve the above objectives, the display device of the present invention includes a time measurement section that measures the time of use from the start of use of the discharge lamp, a lamp voltage upper limit memory section that stores the lamp voltage upper limit, which is the lamp voltage upper limit of the upper limit operable by the discharge lamp, a function memory section that stores the lamp voltage function that predicts changes over the course of use of the lamp voltage, and a remaining time calculation section that calculates the difference between the first time derived from the lamp voltage upper limit and the use time measured by the time measurement section as the remaining time of use of the discharge lamp.

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[0008]

According to this display device, the remaining time calculation section calculates the difference between a first time, which is the time at which the lamp voltage function stored in the function memory section, which predicts the change in the lamp voltage over time of use, reaches the lamp voltage upper limit value, and the usage time measured by the time measurement section, thereby determining the remaining usable time of the discharge lamp. Thus, the display device can calculate the appropriate remaining time corresponding to the characteristics of the discharge lamp by using the lamp voltage function. Here, the usage time from the start of use refers to the cumulative time that the discharge lamp was actually lit from the start of use.

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[0009]

Also, in the above display device, the display device preferably further comprises a lamp voltage detection section that detects the lamp voltage when the discharge lamp is driven, a lamp voltage memory section that stores the lamp voltage detected by the lamp voltage detection section and the time of use at the time of detection, and a function generation section that generates a lamp voltage function based on the lamp voltage and time of use stored in the lamp voltage memory section.

[0010]

According to such a display, the lamp voltage memory section stores the lamp voltage and the time of use detected by the lamp voltage detection section, and the function generation section generates a lamp voltage function based on the stored lamp voltage and the time of use. Thus, the function generation section can more accurately calculate the remaining time corresponding to the discharge lamp being used, in order to generate a lamp voltage function corresponding to the characteristics of the discharge lamp being used. For example, if the least squares method is used to generate the lamp voltage function, the detected lamp voltage can be accurately approximated to the lamp voltage function. Also, the least squares method is a generally known approximation method, and it is easy to realize processing.

[0011]

Also, in the above display device, the lamp voltage detection section detects the lamp voltage at each predetermined usage time interval, the lamp voltage memory section stores the lamp voltage and the time of use at the time of detection at each said predetermined usage time interval, and the function generation section preferably generates a lamp voltage function based on the lamp voltage and the time of use stored at the lamp voltage memory section at each said predetermined usage time interval.

[0012]

According to such a display device, at each predetermined usage time interval, the lamp voltage detection section detects the lamp voltage, the lamp voltage memory section stores the lamp voltage and the usage time at the time of detection, and the function generation section generates a lamp voltage function. Thus, the function generation section can continue to generate a lamp voltage function that follows a change in the lamp voltage of the discharge lamp being used.

[0013]

In addition, in the above display device, the function generation section preferably stops generating the lamp voltage function when the remaining time calculated by the remaining time calculation section becomes less than or equal to the predetermined first remaining time.

[0014]

According to such a display device, the function generation section stops generating the lamp voltage function for each predetermined usage time interval when the remaining time is less than or equal to the predetermined first remaining time. Here, the predetermined first remaining time is the time that the lamp voltage function generated by the function generation section is expected to be less variable and almost fixed. The lamp voltage increases with the passage of time during use. Also, since the lamp voltage function is generated using the lamp voltage and time of use data, for example, by the least squares method, as the number of data points increases with the passage of time of use, the lamp voltage function that is generated will be less variable and mostly fixed. That is, after the lamp voltage function to be generated is almost fixed, the lamp voltage function to be generated shall be stopped. This can reduce the load of the processing because the processing generating the lamp voltage function can be omitted. It should be noted that if the remaining time is determined to be less than or equal to the specified first remaining time, the lamp voltage function generated just before shall be stored, and after the generation of the lamp voltage function is stopped, the remaining time shall be calculated using the stored lamp voltage function.

[0015]

In addition, in the above display device, the display device preferably has a first display section that displays the remaining time calculated by the remaining time calculation section.

[0016]

According to such a display device, there is a first display part that displays the remaining time calculated by the remaining time calculation section. Thus, the display can inform the user of the remaining time.

[0017]

In addition, in the above display device, it is preferable that the display device has a second display part that indicates that the discharge lamp being used will be prompted to be replaced when the remaining time calculated by the remaining time calculation section is less than or equal to the specified second remaining time.

[0018]

According to such a display device, when the remaining time calculated by the remaining time calculation section is less than or equal to the prescribed second remaining time, the second display section shall indicate that the discharge lamp being used is to be replaced. The predetermined second remaining time is the time required to replace the discharge lamp as determined by the discharge lamp specifications. Thus, the display device can inform the user when the remaining time becomes a time that requires replacement of the discharge lamp.

[0019]

In addition, in the above display device, it is preferable that the display device turns off the discharge lamp when the remaining time calculated by the remaining time calculation section is 0 or less.

[0020]

According to such a display device, the discharge lamp is turned off when the remaining time calculated by the remaining time calculation section is 0 or less. This allows the use of the discharge lamp to be limited to voltages within the rated specification range, as it is possible to turn off the discharge lamp that has reached the end-of-life, and thus maintain safety in the use of the discharge lamp.

[0021]

Also, in the above display device, preferably, the discharge lamp is configured as a lamp unit, the lamp section comprising a lamp information memory, the lamp information memory having a lamp voltage memory section and a function memory section.

[0022]

According to such a display device, the lamp section comprises a discharge lamp and a lamp information memory. The lamp information memory then has a lamp voltage memory section and a function memory section. As a result, each lamp section will have a lamp information memory, so it is necessary to replace the lamp, and even when the lamp section is replaced, it is possible to calculate the remaining time specific to the discharge lamp by using the lamp information memory of the lamp section after replacement.

[Best form for implementing the invention]

[0023]

(Embodiments)

Embodiments of the present invention will be described using FIGS. 1-8 below.

[0024]

FIG. 1 is a circuit block diagram illustrating an internal configuration of a projector according to the present embodiment; In the present embodiment, the display device is a projector 100 with a discharge lamp 30 as a light source. Using FIG. 1, an internal configuration of the projector 100 is described.

[0025]

The projector 100 comprises a power supply section 10, a ballast 20, a discharge lamp 30, a lamp information memory 31, a CPU 40, a RAM 50, a ROM 60, a ballast-main board interface 70, a video control processing section 80, a video input section 110, and a video projection section 113. In the present embodiment, the CPU 40, the RAM 50, the ROM 60, the ballast-main board interface 70, the video control processing section 80, and the video input section 110 are mounted on the main board. FIG. 1 also illustrates a screen 200 and an external video output device 300 outside the projector 100.

[0026]

Next, the circuit operation of the projector 100 is described using FIG. 1.

The power supply section 10 enters a commercial power source, such as 100 V AC, to generate the DC power supply voltage required for various operations of the projector 100 and the DC power supply voltage for operating the ballast 20. The ballast 20 is a device that causes the discharge lamp 30 to illuminate and drive. The discharge lamp 30 serves as a light source for the projector 100.

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[0027]

The discharge lamp 30 and the lamp information memory 31 are configured as a lamp unit, and the lamp information memory 31 is provided in the lamp section via a material with a low thermal conductivity so as not to be affected by the heat of the discharge lamp 30. For materials with low thermal conductivity, for example, using plastic, etc., the distance between the discharge lamp 30 and the lamp information memory 31 is increased. In addition, the lamp section can be detached from the projector 100. When the lamp section is attached to the projector 100, the discharge lamp 30 is connected to the ballast 20, and the lamp information memory 31 is attached to the main board via a connector, etc. Here, lamp information memory 31 is a non-volatile memory, and in the present embodiment is a FlashROM. The lamp information memory 31 stores the information of the usage time, lamp voltage, and lamp voltage function of the discharge lamp 30 as separate information of the discharge lamp 30, which also constitutes the lamp unit, as described below.

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[0028]

The lamp information memory 31, the CPU 40, the RAM 50, the ROM 60, and the video control processing section 80 are connected to each other by a bus line on the main board. The ROM 60 stores, for example, programs that control lamps, programs that generate lamp voltage functions, programs that calculate the available remaining time of lamps, programs that control video, programs that perform On Screen Display (OSD) processing, programs that project video, etc. The CPU 40 executes these programs using the RAM 50 as the work area. The ballast-main board interface 70 is an interface for transmitting an indication signal for lamp voltage detection from the CPU 40 to the ballast 20 and receiving lamp voltage information detected by the ballast 20.

[0029]

The video input section 110 inputs video signals from the external video output device 300. The video control processing section 80 processes the video signals entered by the video input section 110 as necessary, and also superimposed the OSD display on the video. The video projection section 113 projects video signals output from the video control processing section 80 into the screen 200 as video.

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[0030]

FIG. 2 is a circuit block diagram illustrating a ballast internal configuration of a projector; Using FIG. 2, a ballast internal configuration of the projector 100 is described.

[0031]

Ballast 20 includes an EMI filter 21, a down converter 22, an inverter circuit 23, and an igniter circuit 24. Within the ballast 20, a voltage detection circuit 25, an A/D converter 26, a communication circuit 27, and a ballast control circuit 28 are provided as a ballast control section.

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[0032]

Next, the circuit operation of the ballast 20 is described using FIG. 2.

The DC voltage input from the power supply section 10 is cut off by the EMI filter 21 and bucked down by the down converter 22. The stepped-down DC current is converted by the inverter circuit 23 to an alternating rectangular wave current (light source driven power). The igniter circuit 24 performs an isolation break between the electrodes of the discharge lamp 30 to prompt the start of the discharge lamp 30.

[0033]

On the other hand, the voltage detection circuit 25 in the ballast control section measures the DC voltage that the down converter 22 has stepped down by means of an indication signal from the ballast control circuit 28 that is instructed by the main board side. Use this DC voltage as the lamp voltage. The measured lamp voltage is converted from an analog value to a digital value by the A/D converter 26. The communication circuit 27 transmits the digitally valued lamp voltage to the main board side via the ballast-main board interface 70. In addition, the communication circuit 27 receives an indication signal for detecting the lamp voltage from the main board side and communicates it to the ballast control circuit 28.

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[0034]

FIG. 3 is a functional block diagram illustrating a functional configuration of a projector; Using FIG. 3, a functional configuration of the projector 100 is described.

[0035]

The projector 100 comprises a power supply section 10, a ballast 20, a discharge lamp 30, a video input section 110, a video signal processing section 111, an OSD processing section 112, a video projection section 113, a video control section 114, an operation reception section 115, a control section 116, a lamp control section 117, a time measurement section 118, a lamp voltage detection section 119, a lamp voltage memory section 120, a function generation section 121, a function memory section 122, a lamp voltage upper limit memory section 123, a remaining time calculation section 124, a lamp voltage comparison section 125, and a remaining time comparison section 126. Here, the three combined functional parts of the video control section 114, the video signal processing section 111, and the OSD processing section 112 are referred to as the video control processing section 80 in FIG. 1.

[0036]

The operation of the projector 100 is then described using the functional configuration.

The power supply section 10 connects a power cable not shown in the drawings to supply power to the projector 100. The ballast 20 receives a supply of power from the power supply section 10 to generate power for driving the discharge lamp 30. Then, the ballast 20 illuminates the discharge lamp 30 according to the instructions from the lamp control section 117. The ballast 20 also outputs the lamp voltage measured by the internal voltage detection circuit 25 (see FIG. 2) to the lamp voltage detection section 119.

[0037]

The video input section 110 enters the video signal from an external video output device 300 (see FIG. 1). The video signal input is processed as necessary by the video signal processing section 111. Video processing refers to image processing such as magnification and shrinkage, trapezoidal correction processing, etc. Next, the OSD processing section 112 superimposed the OSD display on the video that was processed as necessary. The video projection section 113 projects video signals output from the OSD processing section 112 as video. The video control section 114 controls instructions for video processing to the video signal processing section 111, OSD processing section 112, and video projection section 113 at the instruction of the control section 116.

[0038]

The operation reception section 115 receives functional operation instructions for the projector 100 by a user using an operation section such as an unillustrated key switch that makes up the projector 100, or functional operation instructions for the projector 100 by a user using a remote control that is provided separately from the projector 100 that is received by the unillustrated remote control receiving section that makes up the projector 100. The control section 116 supervises and controls the projector 100 in order to perform function operation, etc. corresponding to the function operation instructions received by the operation reception section 115. Other control details performed by the control section 116 include, for example, instructions for video signal processing to the video control section 114, instructions for time measurement to the time measurement section 118, instructions for turning on/off the discharge lamp 30 to the lamp control section 117, and control, etc. of the cooling fan, etc. (description in the drawings omitted).

[0039]

The lamp control section 117 uses the ballast 20 to control the lighting of the discharge lamp 30 according to the instructions from the control section 116. The time measurement section 118 measures the usage time (cumulative lighting time) of the discharge lamp 30 according to the instructions of the control section 116. In addition, the time measurement section 118 performs periodic time measurement to detect the lamp voltage, and instructs the lamp voltage detection section 119 when to detect the lamp voltage. At the instruction from the time measurement section 118, the lamp voltage detection section 119 sends a detection indication signal for the lamp voltage of the discharge lamp 30 to the ballast 20 and receives the lamp voltage as a result of the detection. The lamp voltage memory section 120 inputs the lamp voltage from the lamp voltage detection section 119 and stores it in the lamp information memory 31 (see FIG. 1). Furthermore, the lamp voltage memory section 120 inputs the usage time when the lamp voltage is detected from the time measurement section 118 and stores it in the lamp information memory 31 in conjunction with the lamp voltage.

[0040]

The function generation section 121 uses the lamp voltage and usage time stored in the lamp voltage memory section 120 to generate the lamp voltage function. The method of generating the lamp voltage function is described below. Function memory section 122 stores the lamp voltage function generated by the function generation section 121 as a function in RAM 50 (see FIG. 1) or lamp information memory 31. The lamp voltage upper limit memory section 123 stores the lamp voltage upper limit value (see FIG. 1), which is the lamp voltage upper limit at which the discharge lamp 30 used in the projector 100 is operable. Here, the upper lamp voltage limit is the voltage value determined by the specifications of the discharge lamp 30 used.

[0041]

Remaining time calculation section 124 calculates the available remaining time for discharge lamp 30 by instructions from control section 116. Here, the calculation method of the remaining time is shown below. The remaining time calculation section 124 calculates the time at which the lamp voltage function reaches the lamp voltage upper limit using the lamp voltage upper limit stored in the lamp voltage upper limit memory section 123 and the lamp voltage function stored in the function memory section 122, and uses it as the first time. This calculated first time is the lifespan of the discharge lamp 30. Furthermore, the remaining time calculation section 124 uses the current use time of the discharge lamp 30 measured by the time measurement section 118 to calculate the difference between the first time and time. The remaining time calculation section 124 then notifies the control section 116 with the calculated difference value as the remaining time. The remaining time indicates the remaining time in the lifespan of discharge lamp 30.

[0042]

In addition, the lamp voltage comparison section 125 compares the lamp voltage detected by the lamp voltage detection section 119 with the lamp voltage upper limit stored by the lamp voltage upper limit memory section 123, determines whether the lamp voltage is greater than or equal to the lamp voltage upper limit, and notifies the control section 116. Furthermore, the lamp voltage comparison section 125 compares the lamp voltage and the lamp voltage upper limit value with the value subtracted from the predetermined voltage, determines whether the lamp voltage is greater than or equal to the value subtracted from the lamp voltage upper limit value, and notifies the control section 116.

[0043]

In addition, the remaining time comparison section 126 compares the remaining time calculated by the remaining time calculation section 124 with the predetermined first remaining time described below, determines whether the remaining time is less than or equal to the predetermined first remaining time, and notifies the function memory section 122. Furthermore, the remaining time comparison section 126 compares the remaining time with the predetermined second remaining time described below, determines whether the remaining time is less than or equal to the predetermined second remaining time, and notifies the control section 116. Furthermore, the remaining time comparison section 126 compares the remaining time to 0 hours, determines whether the remaining time is less than or equal to 0 hours, and notifies the control section 116.

[0044]

By the configuration as described above, the projector 100 can calculate the available remaining time of the discharge lamp 30 while projecting the image with the discharge lamp 30 as a light source.

[0045]

The remaining time calculation process of the projector 100 in this embodiment will then be described using a flowchart.

[0046]

FIG. 4 is a flowchart of a projector remaining time calculation process according to an embodiment. The projector 100 detects the lamp voltage at each predetermined usage time interval, and uses the results to generate a lamp voltage function and calculate the remaining time. In the present embodiment, the predetermined time interval of use is 50 time intervals, and the flowchart of FIG. 4 represents a residual time calculation process performed every 50 time intervals. Here, the usage time shall be measured as described above, the cumulative time at which the discharge lamp 30 is lit. Using FIG. 4, a residual time calculation process of the projector 100 is described every 50 hours.

[0047]

The lamp voltage detection section 119 sends an indication signal to the ballast 20 for detecting the lamp voltage of the discharge lamp 30 and receives the lamp voltage detected by the ballast 20 (step S100). The lamp voltage memory section 120 then stores the detected lamp voltage and the usage time when the lamp voltage is detected in the lamp information memory 31 (step S101).

[0048]

Here, the lamp information memory 31 stores the usage time and lamp voltage as data, as shown in FIG. 6. It should be noted that FIG. 6 is a diagram illustrating an array of data in a lamp information memory. As shown in array H1, the leading address of lamp information memory 31 stores the lamp voltage function. However, since the lamp voltage function is written when the conditions described below are reached, the initial value is stored as "0." The following address of the lamp voltage function stores the usage time every 50 hours and the lamp voltage detected at that time. It should be noted that FIG. 6 shows the data array for the time of use from 0 (H: hours) to 300 (H) and the lamp voltage (V: volts) at that time, but the data from 300 (H) and onward shall also be stored sequentially.

[0049]

Returning to FIG. 4, the function generation section 121 then determines whether the lamp voltage function is stored in the lamp information memory 31 (step S102). If "0" is stored in the leading address of the lamp information memory 31, the function generation section 121 determines that the lamp voltage function is not stored (step S102: NO). If the lamp voltage function is not stored, the function generation section 121 generates the lamp voltage function using all usage time and lamp voltage data stored in the lamp information memory 31 (step S103).

[0050]

In this embodiment, a least squares exponential approximation is used as a method of generating a lamp voltage function. This allows the lamp voltage to approximate an increase change with usage time to an exponential curve. The exponentially approximate lamp voltage function is represented by the following equation (1) as a general formula:

$$y=a*eb^{bx} \quad \dots (1)$$

It should be noted that x indicates the time of use (H: hours), y indicates the lamp voltage (V: volts), e is the Napier number, and a and b are coefficients.

[0051]

Here, FIG. 7 is a graph of lamp voltage functions generated using least squares exponential approximations. In the graph of FIG. 7, the x-axis indicates the time of use and the y-axis indicates the lamp voltage. The points plotted on the graph show data for the usage time and lamp voltage of the sequence H1 shown in FIG. 6. Function F1 is a lamp voltage function that is generated by the data of the plotted points described above using the least squares exponential approximation. Function F1 is stored in RAM 50 by function memory section 122.

[0052]

Returning to FIG. 4, the remaining time calculation section 124 then uses the lamp voltage function and the current usage time to calculate the available remaining time of the discharge lamp 30 (step S104). Specifically, the remaining time calculation section 124 calculates the time at which the lamp voltage function reaches the lamp voltage upper limit using the lamp voltage upper limit stored in the lamp voltage upper limit memory section 123 and the lamp voltage function to be the first time. This calculated first time is the lifespan of the discharge lamp 30. In the present embodiment, the upper lamp voltage limit is 130 V. Furthermore, the remaining time calculation section 124 calculates the difference between the current use time and the first time, and the calculated difference value is the remaining time. The remaining time indicates the remaining time in the lifespan of the discharge lamp 30.

[0053]

The calculation of the remaining time will now be described using FIG. 8. FIG. 8 is a graph representing the relationship between lamp voltage function and usage time. In the graph of FIG. 8, the x-axis indicates the time of use and the y-axis indicates the lamp voltage. On the x-axis, the first time T1 and the current usage time T2 are shown. Also, on the y-axis, the upper lamp voltage limit V0 is shown. Function F1 shows a lamp voltage function similar to FIG. 7. As shown in the graph in FIG. 8, the function F1 and the lamp voltage upper limit V0 to the first time T1 is determined. Further, the remaining time t can be calculated from the first time T1 and the current usage time T2. Here, the method of calculating the first time T1 and the method of calculating the remaining time t will be described by replacing the function F1 with the general formula (1).

[0054]

Applying the first time T1 and the lamp voltage upper limit V0 to formula (1) results in the following formula (2).

$$V0=a*b^{T1} \quad \dots (2)$$

Here, by calculating and organizing the natural logarithms of both sides of the formula (2), the first time T1 is represented by the following formula (3):

$$T1=(\log V0-\log a)/b \quad \dots (3)$$

The remaining time t can then be calculated by subtracting the current usage time T2 from the first time T1. Thus, the remaining time t is represented by the following equation (4):

$$t=T1-T2 \quad \dots (4)$$

[0055]

Returning to FIG. 4, the remaining time comparison section 126 then determines whether the remaining time is less than or equal to the predetermined first remaining time (step S105). The predetermined first remaining time is the time that the lamp voltage function generated by the function generation section 121 is expected to be less variable and almost fixed. In this embodiment, the predetermined first remaining time is 300 hours, but is not limited to 300 hours. If it is determined that the remaining time is not less than or equal to the specified first remaining time (step S105: NO), the remaining time calculation process shown in this flowchart is terminated. If the remaining time is determined to be less than or equal to the predetermined first remaining time (step S105: YES), the function memory section 122 stores the lamp voltage function stored in the RAM 50 in the lamp information memory 31 (step S106). In other words, the lamp voltage function is written to the address (first address) of the lamp voltage function of array H1 of FIG. 6. Then, the remaining time calculation process shown in this flowchart is completed.

[0056]

On the other hand, in step S102, the case where the lamp voltage function was stored in the lamp information memory 31 (step S102: YES) is described. Here, in step S107 and step S108, the detected lamp voltage is compared with the voltage value subtracted from the lamp voltage upper limit or the lamp voltage upper limit. This is to detect that the discharge lamp 30 has fallen outside the rated specification range of voltage or is close to being outside the rated specification when the lamp voltage has unexpectedly risen (the detected lamp voltage has deviated significantly from the lamp voltage function).

[0057]

The lamp voltage comparison section 125 determines whether the lamp voltage detected this time is greater than or equal to the upper limit of the lamp voltage (step S107). If the lamp voltage is greater than or equal to the upper limit of the lamp voltage (step S107: YES), the lamp control section 117 turns off the discharge lamp 30 (step S112). Specifically, the lamp voltage comparison section 125 notifies the control section 116 that the discharge lamp 30 is in a state of voltage outside the rated specifications, and the control section 116 instructs the lamp control section 117 to turn off the discharge lamp 30. Then, the remaining time calculation process shown in this flowchart is completed.

[0058]

If the lamp voltage is not greater than or equal to the lamp voltage upper limit (step S107: NO), the lamp voltage comparison section 125 determines whether the lamp voltage is greater than or equal to the lamp voltage upper limit minus the predetermined voltage (step S108). Here, the value subtracted from the upper limit of the lamp voltage is the voltage that requires replacement of the discharge lamp 30 as determined from the specifications of the discharge lamp 30. In this embodiment, the predetermined voltage is 5 V (volts), but is not limited to 5 V. If the value is greater than or equal to 5 V subtracted from the upper limit of the lamp voltage (step S108: YES), the video control section 114 displays a message prompting the lamp to be replaced in the second display section (step S113). In the present embodiment, the second indication is an OSD indication superimposed on a video projected by the projector 100. As a specific operation, the lamp voltage comparison section 125 notifies the control section 116 that the discharge lamp 30 is close to a voltage outside the rated specifications, and the control section 116 instructs the video control section 114 to display a message prompting the lamp replacement. The video control section 114 instructs the OSD processing section 112 to display an OSD message prompting the lamp replacement. Then, the remaining time calculation process shown in this flowchart is completed.

[0059]

Next, if the lamp voltage is not greater than or equal to the value subtracted by 5 V from the lamp voltage upper limit (step S108: NO), the remaining time calculation section 124 uses the lamp voltage function and the current usage time to calculate the available remaining time of the discharge lamp 30 (step S109). The lamp voltage function used here uses the lamp voltage function stored in the lamp information memory 31. The remaining time calculation process is similar to step S104.

[0060]

Next, the remaining time comparison section 126 determines whether the remaining time calculated by the remaining time calculation section 124 is less than or equal to 0 hours (step S110). If the remaining time is less than or equal to 0 hours (step S110: YES), the lamp control section 117 turns off the discharge lamp 30 (step S112). Then, the remaining time calculation process shown in this flowchart is completed.

[0061]

If the remaining time is not less than 0 hours (step S110: NO), the remaining time comparison section 126 determines whether the remaining time is less than or equal to the predetermined second remaining time (step S111). The predetermined second remaining time shall be the time required to replace the discharge lamp as determined by the discharge lamp specifications. In the present embodiment, the predetermined second remaining time is 100 hours, but is not limited to 100 hours. If the remaining time is less than or equal to the predetermined second remaining time (step S111: YES), the video control section 114 displays a message prompting the lamp to be replaced in the second display (step S113). Then, the remaining time calculation process shown in this flowchart is completed. Also, if the remaining time is not less than the predetermined second remaining time (step S111: NO), the remaining time calculation process shown in this flowchart is terminated.

[0062]

The projector remaining time indication process in this embodiment will then be described using a flowchart.

[0063]

FIG. 5 is a flowchart of a projector time remaining indication process according to the present embodiment. The remaining time display process is the process performed when the remaining time display operation is performed by the user. In the present embodiment, the specification is to provide a "Time Remaining Up to Lamp End-of-Life" item in the function menu implemented as software in projector 100, and to display the remaining time to end-of-life by a user operating an operation section such as a remote control or key switch and instructing projector 100. Using FIG. 5, the time remaining indication processing of the projector 100 is described.

[0064]

The function generation section 121 determines whether the lamp voltage function is stored in the lamp information memory 31 (step S200). If "0" is stored in the address of the lamp voltage function, the function generation section 121 determines that the lamp voltage function is not stored (step S200:NO). If the lamp voltage function is not stored, the function generation section 121 generates the lamp voltage function using all usage time and lamp voltage data stored in the lamp information memory 31 (step S201). The processing of the lamp voltage function generation is similar to step S103 of the flowchart of FIG. 4.

[0065]

On the other hand, in step S200, if the lamp voltage function is stored in the lamp information memory 31 (step S200: YES), the lamp voltage function stored in the lamp information memory 31 shall be used in the subsequent processing, and it transitions to step S202.

[0066]

The remaining time calculation section 124 then uses the lamp voltage function and the current usage time to calculate the available remaining time of the discharge lamp 30 (step S202). The processing of the remaining time calculation is the same as step S104 of the flowchart of FIG. 4.

[0067]

Next, the video control section 114 displays the remaining time in the first display section (step S203). In the present embodiment, the second indication is an OSD indication superimposed on a video projected by the projector 100. In other words, the OSD processing section 112 superimposed the remaining time as an OSD display for the video projected by the projector 100. The remaining time is displayed for a few seconds, allowing the user to recognize it.

[0068]

Next, the remaining time comparison section 126 determines whether the remaining time calculated by the remaining time calculation section 124 is less than or equal to 0 hours (step S204). If the remaining time is less than or equal to 0 hours (step S204: YES), the lamp control section 117 turns off the discharge lamp 30 (step S206). The specific processing and operation is similar to step S112 of FIG. 4. Then, the remaining time calculation process shown in this flowchart is completed.

[0069]

If the remaining time is not less than 0 hours (step S204: NO), the remaining time comparison section 126 determines whether the remaining time is less than or equal to the predetermined second remaining time (step S205). As previously described, the predetermined second remaining time in the present embodiment is 100 hours. If the remaining time is less than or equal to the predetermined second remaining time (step S205: YES), the video control section 114 displays a message prompting the lamp to be replaced in the second display (step S207). The specific processing and operation is similar to step S112 of FIG. 4. Then, the remaining time calculation process shown in this flowchart is completed. If the remaining time is not less than the predetermined second remaining time (step S205:NO), the remaining time indication process shown in this flowchart is terminated.

[0070]

According to the embodiments described above, the following effects are obtained:

(1) The projector 100 detects the lamp voltage, generates a lamp voltage function, and uses the lamp voltage function to calculate the remaining time from the current usage time to the end-of-life of the discharge lamp 30. Therefore, the remaining time can be calculated more accurately than the method of determining the remaining time based on the difference in the usage time by determining the lamp lifespan in advance, as is the case with conventional methods.

[0071]

(2) Projector 100 also uses a least squares method when generating a lamp voltage function. This allows the lamp voltage function to approximate high accuracy from the lamp voltage and usage time. Also, the least squares method is a generally known approximation method and is a suitable method because it is easy to achieve with software, etc. Thus, the projector 100 can calculate an accurate remaining time from a lamp voltage function approximated to high accuracy.

[0072]

(3) The projector 100 also detects the lamp voltage, stores the lamp voltage and the time of use at the time of detection, and generates a lamp voltage function at each predetermined usage time interval. This allows the projector 100 to generate a lamp voltage function that follows a change in the lamp voltage of the discharge lamp 30 being used. That is, a lamp voltage function that always reflects the detected lamp voltage can be generated. Thus, the projector 100 can calculate the exact remaining time from the lamp voltage function following the change in lamp voltage.

[0073]

(4) The projector 100 also stops generating the lamp voltage function for each predetermined usage time interval when the remaining time is less than or equal to the predetermined first remaining time. Then, the remaining time is calculated using the last generated lamp voltage function. It should be noted that the predetermined first remaining time is the time at which the change in the lamp voltage function generated by the projector 100 is expected to converge. This can omit processing to generate the lamp voltage function after the predetermined first remaining time or less, and can reduce the load of the software processing. Thus, an improvement in operational responsiveness as projector 100 can be expected.

[0074]

(5) The projector 100 may also allow the user to recognize the calculated remaining time. Thus, the user can understand the time of end-of-life of the discharge lamp 30. Further, the user can replace the discharge lamp 30 or prepare for replacement by knowing the remaining time. This makes it possible to prevent the discharge lamp 30 from going out due to the lamp reaching its end-of-life while a user is giving a presentation using the projector 100, for example.

[0075]

(6) The projector 100 may also be recognized by displaying a message prompting the user to replace the lamp when it is determined that the remaining time is less than or equal to a predetermined second remaining time that requires the replacement of the discharge lamp 30. Thus, the user can replace the discharge lamp 30 before the discharge lamp 30 reaches its end-of-life.

[0076]

(7) The projector 100 may also turn off the discharge lamp 30 when it determines that the remaining time is less than or equal to 0 hours indicating the end-of-life of the discharge lamp 30. Therefore, it can be avoided that the discharge lamp 30 will continue to be used outside of the rated specification range voltage. Thus, safety can be maintained in the use of the discharge lamp 30.

[0077]

(8) Also, since the projector 100 stores the lamp voltage and usage time and lamp voltage function information in the lamp information memory 31 provided in the lamp unit, the remaining time corresponding to the discharge lamp 30 of the replaced lamp section can be calculated even if the lamp section is replaced. Thus, the user can replace the lamp section of the discharge lamp 30, either new or used, with a discharge lamp 30 of the same specification. The remaining time corresponding to the discharge lamp 30 can be determined. In addition, corresponding to the discharge lamp 30, a message can be displayed to prompt lamp replacement, and the discharge lamp 30 can also be turned off when the discharge lamp 30 has reached its end-of-life.

[0078]

While embodiments of the present invention have been described above, the present invention is not in any way limited to such embodiments, and of course may be implemented in various forms to the extent that it does not deviate from the summary of the present invention. The following are examples of variations.

[0079]

(Variation 1) In the above embodiment, the display device is a projector 100, but may be a rear projection television. In addition, the present invention can be practiced if the display device comprises a discharge lamp as a light source.

[0080]

(Variation 2) In the above embodiment, the first display part and the second display part were to be superimposed as an OSD display on the projection image, but the first display part and the second display part may be a display part such as a liquid crystal display, etc., provided on the housing of the projector 100. In this way, the OSD display does not obstruct the projection image, and the user can check the remaining time by viewing the liquid crystal display. The first display and the second display can also be LEDs (Light Emitting Diodes). This allows the remaining time to be expressed by illuminating/off/blinking the LEDs and controlling the color, as well as a message prompting the lamp to be replaced. For example, if the remaining time is greater than 500 hours, greater than 300 hours and less than 500 hours, greater than 100 hours and less than 300 hours, or prompting a lamp change of less than 100 hours, the LEDs can be used to describe the remaining time. This will reduce the load on software processing.

[0081]

(Variation 3) Also, in the above embodiment, the indication of the remaining time was to be expressed as a number, but the indication of the remaining time may be made as intended. For example, use time and remaining time may be represented in a diagram such as a bar graph. In this way, the user can graphically recognize the current use time and the remaining time.

[0082]

(Variation 4) In the above embodiment, the time interval for performing the residual time calculation process is set to 50 time intervals as the predetermined usage time interval, but may be a shorter interval. For example, it may be a 1-hour interval or a 10-minute interval. In this way, if there is a sudden change in the lamp voltage, the reflection to the lamp voltage function is performed in a short period of time, and the calculation of the remaining time becomes more accurate. In addition, even when the end-of-life of the discharge lamp 30 is near or when the discharge lamp 30 has reached its end-of-life, the detection interval is short, so it is possible to display a message prompting lamp replacement and turn off the discharge lamp 30 early.

[0083]

(Variation 5) In the above embodiment, the time interval for performing the residual time calculation process is set to a predetermined usage time interval, but the residual time calculation process may be performed even when the projector 100 is turned on, the discharge lamp 30 is lit, and the lamp voltage of the discharge lamp 30 is stable. It should be noted that the time from when the discharge lamp 30 is lit to when the lamp voltage stabilizes is about 5 minutes. In this way, the remaining time of the discharge lamp 30 can be calculated in a short period of time (about 5 minutes) after the projector 100 is powered on, so even when the end-of-life of the discharge lamp 30 is near or when the discharge lamp 30 has reached its end-of-life, the display of a message prompting lamp replacement and the discharge lamp 30 can be turned off early from the time of powering on of the projector 100.

[0084]

(Variation 6) In the above embodiment, the remaining time indication processing is to be performed at the instruction of the user, but the remaining time indication processing may also be performed when the projector 100 is turned on and the discharge lamp 30 is lit. The user can then recognize the available remaining time of the discharge lamp 30 immediately after powering on the projector 100. That is, even without the user instructing to check the remaining time, the remaining time can be automatically displayed immediately after the projector 100 is powered on and can be recognized by the user.

[0085]

(Variation 7) In the above embodiment, the upper limit of the lamp voltage was to be stored in the ROM 60, but may be stored in the lamp information memory 31. In this way, when using a discharge lamp with different specifications for the lamp voltage upper limit, replacing the lamp section replaces the lamp information memory 31 and also exchanges the lamp voltage upper limit, lamp voltage function, usage time and lamp voltage data in the lamp information memory 31. Thus, the value for the first time determined by the lamp voltage function and the lamp voltage upper limit is changed, allowing the calculation of the remaining time corresponding to the discharge lamp with different specifications.

[0086]

(Variation 8) In the above embodiment, the generation of the lamp voltage function was to be performed using all usage time and lamp voltage data stored in the lamp information memory 31, but the data used to generate the lamp voltage function may be selectable. For example, the most recent 20 usage times and lamp voltage data can be used to generate the lamp voltage function. Thus, if the lamp voltage characteristics of the discharge lamp 30 make it unsuitable to use the data from the beginning of use of the discharge lamp 30 for the generation of the lamp voltage function (e.g., if the change characteristics of the lamp voltage change significantly over time), only the most recent data can be used to generate a valid lamp voltage function. In addition, if the number of data used is reduced, the software processing load of approximation processing by the least squares method is reduced, so it is expected to improve the operation responsiveness as projector 100.

[0087]

(Variation 9) In the above embodiment, the residual time calculation process of the discharge lamp 30 is to be performed on the main board, but the residual time calculation process may be performed within the ballast 20. For example, the remaining time calculated in the ballast 20 may be replaced with two bits of information, allowing the projector 100 to express that two bits of information with two LEDs. As an example, it can be expressed as: If the states of the two LEDs are (off, off), the remaining time is greater than 300 hours; if they are (on, off), the remaining time is greater than 100 hours and less than or equal to 300 hours; if they are (on, on), the remaining time is less than or equal to 100 hours. In this way, software processing such as residual time calculation processing and OSD display processing on the main board side are reduced, and it can be expected to improve operation responsiveness as the projector 100.

[0088]

(Variation 10) In the above embodiment, the approximation method for generating the lamp voltage function was a least squares exponential approximation, but other approximations may be able to select a least squares logarithmic approximation, polynomial approximation, power approximation, etc. The characteristics of the discharge lamp 30 used thus allow the most suitable approximation to be made and to generate an optimal lamp voltage function for calculating the remaining time. It should be noted that the selection of the approximation method may be made by providing the "Data approximation method selection when generating a lamp voltage function" item in the functional menu implemented as software in the projector 100, and allowing the user to select it, or may incorporate the optimal approximation method for the discharge lamp 30 to be used in advance into the program.

10

[0089]

(Variation 11) In the above embodiment, the lamp voltage function was to be generated while detecting the lamp voltage, but the lamp voltage function may be stored in advance. For example, the lamp voltage function corresponding to the characteristics of the discharge lamp 30 used can be stored in the lamp information memory 31. In this way, it is possible to calculate the appropriate remaining time corresponding to the characteristics of the lamp voltage of the discharge lamp 30. In addition, since processing to generate the lamp voltage function while detecting the lamp voltage is not required, software processing can be reduced, and improved operational responsiveness as projector 100 can be expected.

[Brief Description of the Drawings]

[0090]

[FIG. 1] Circuit block diagram showing the internal configuration of the projector according to an embodiment.

20

[FIG. 2] Circuit block diagram showing the ballast internal configuration of the projector.

[FIG. 3] Functional block diagram showing the functional configuration of the projector.

[FIG. 4] Flowchart of the projector remaining time calculation process.

[FIG. 5] Flowchart of the projector remaining time display process.

[FIG. 6] Diagram showing the data array in the lamp information memory.

[FIG. 7] Graph of lamp voltage function generated using the least squares exponential approximation.

[FIG. 8] Graph showing the relationship between lamp voltage function and usage time.

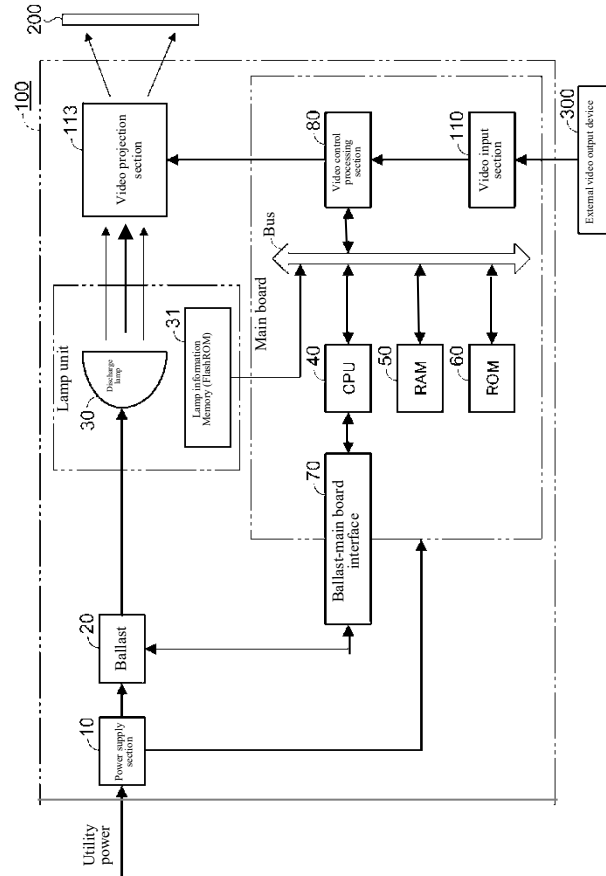
[Explanation of References]

[0091]

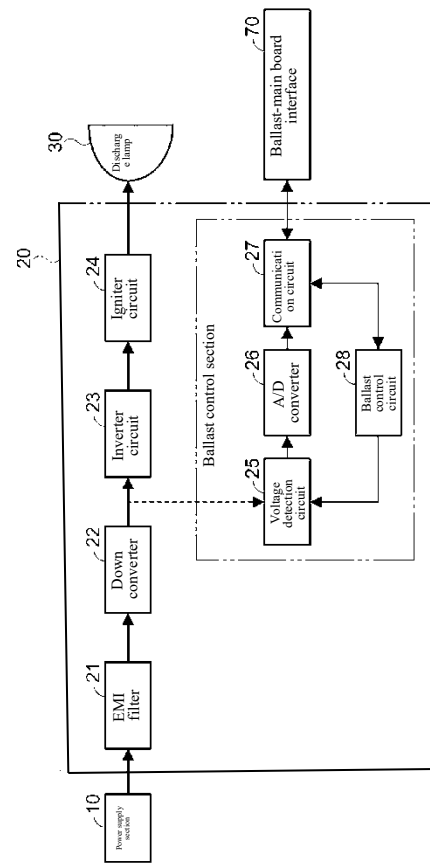
10...power supply section, 20...ballast, 21...EMI filter, 22...down converter, 23...inverter circuit, 24...igniter circuit, 25...voltage detection circuit, 26...A/D converter, 27...communication circuit, 28...ballast control circuit, 30...discharge lamp, 31...lamp information memory, 40...CPU, 50...RAM, 60...ROM, 70...ballast-main board interface, 80...video control processing section, 100...projector, 110...video input section, 111...video signal processing section, 112...OSD processing section, 113...video projection section, 114...video control section, 115...operation reception section, 116...control section, 117...lamp control section, 118...time measurement section, 119...lamp voltage detection section, 120...lamp voltage memory section, 121...function generation section, 122...function memory section, 123...lamp voltage upper limit memory section, 124...remaining time calculation section, 125...lamp voltage comparison section, 126...remaining time comparison section, 200...screen, 300...external video output device.

30

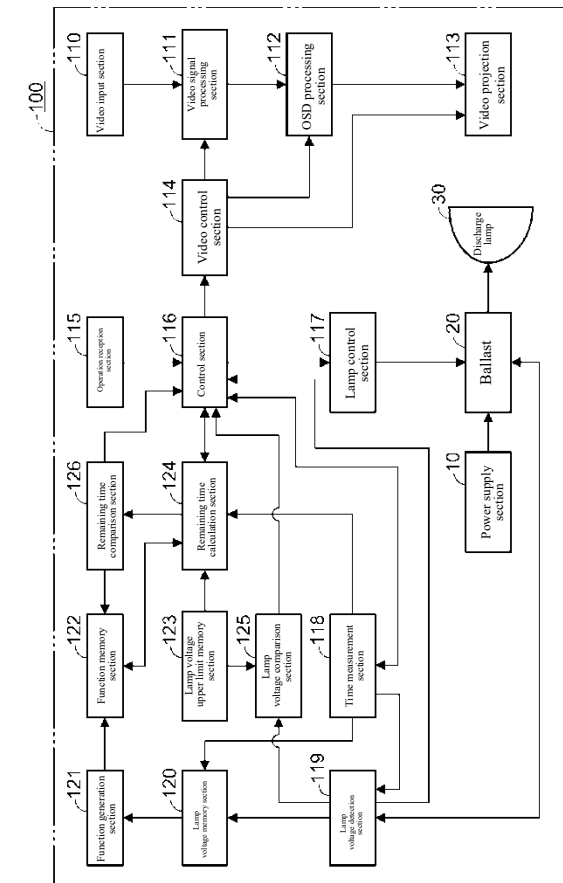
[FIG. 1]



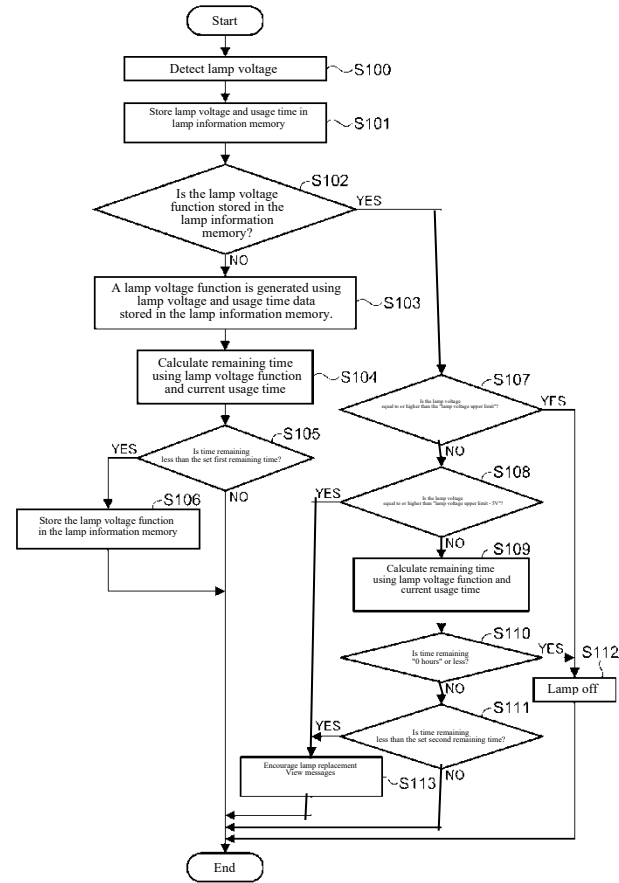
[FIG. 2]



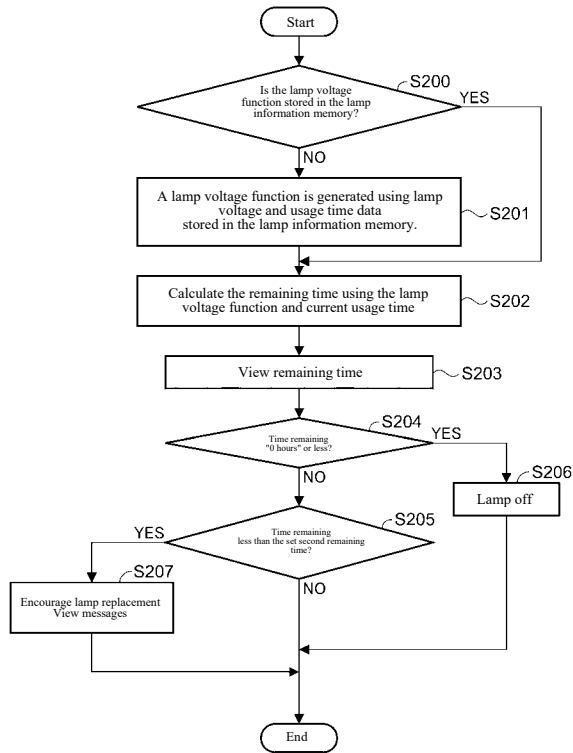
[FIG. 3]



[FIG. 4]



[FIG. 5]

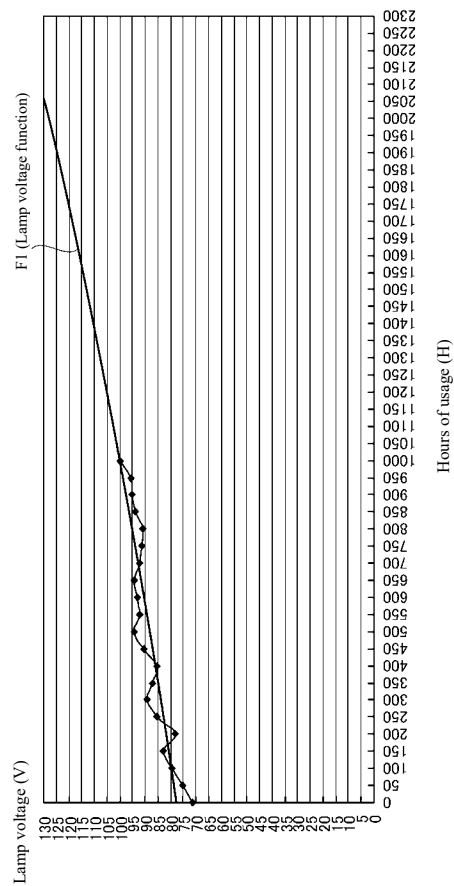


[FIG. 6]

Lamp information memory H1

$y = a * e^{bx}$ (Lamp voltage function)	
0(H)	71.5(V)
50(H)	75.2(V)
100(H)	79.6(V)
150(H)	83.0(V)
200(H)	78.0(V)
250(H)	85.4(V)
300(H)	89.4(V)

[FIG. 7]



[FIG. 8]

