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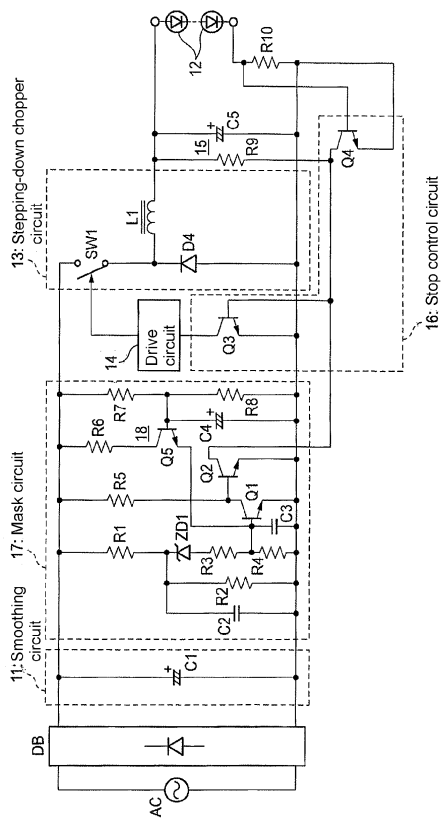
(54) LED power source device

(57) [Summary]

[Object] To provide an LED power source device able to prevent an excessive current to an LED.

[Means for Settlement] An LED power source device 10 includes: a rectifier DB; an output power source adjustment circuit 13 for supplying electric power to an LED 12; a drive circuit 14; a stop control circuit 16 for judging existence and nonexistence of the LED 12 by detecting an electric current flowing to the LED 12 and for operating to stop the drive circuit 14 upon detection of the nonexistence of the LED 12; and a mask circuit 17 for monitoring the voltage after the rectification to control the stop control circuit 16, wherein in the case where the voltage after the rectification is a predetermined value or less of the mask circuit 17, the operation of the stop control circuit 16 is not prohibited.

Fig. 1



EP 2 525 627 A2

Description

[Field of the Invention]

[0001] The present invention relates to an LED power source device employing an LED as a light source.

[Background Art]

[0002] Conventionally, an LED power source including: a rectifying circuit; a power supply circuit connected between output terminals of the rectifying circuit to output a constant current; and a plurality of LEDs connected in series between output terminals of the power supply circuit has been known (for example, refer to Patent Literature 1).
Patent Literature 1 includes: a smoothing capacitor; and a stepping-down chopper circuit for stepping down a voltage between both terminals of the smoothing capacitor.

[Conventional Technique Document]

[Patent Literature]

[0003] [Patent Literature 1] JPA2009-33098 (Fig. 1, Paragraphs 0033 and 0034)

[Disclosure of the Invention]

[Problems to be solved by the Invention]

[0004] Generally, in order to reduce the output current ripples, an output smoothing capacitor of a stepping-down chopper circuit has a relatively-large capacity.
Accordingly, even when a power source is turned off, discharging requires time, and especially when the power source is turned off after detachment of an LED, the discharging requires time more than a few seconds in the case where an active discharging circuit is not employed.
In addition, in order to prevent an overvoltage application to the LED, some circuits include means adapted to stop driving the stepping-down chopper circuit after detecting the overvoltage of a voltage between both terminals of the LED.
However, a level at which the over voltage is detected, is set to be higher than a total forward direction voltage of the LED, and accordingly when the LED is attached again immediately after detached, there is a possibility that an excessive current flows to the LED to damage an LED element.

[0005] Then, as shown in Fig. 4, to solve the above-mentioned problem, an LED power source device 50 including: a rectifying circuit DB for rectifying an alternating-current power source in full waves; and a smoothing circuit 51 for smoothing a rectified pulsating voltage is proposed.
The above-mentioned conventional LED power source device 50 includes a stepping-down chopper circuit 53 for supplying an electric current to an LED 52 so as to be substantially constant with use of the smoothed voltage as a power source.
In addition, the above-mentioned conventional LED power source device 50 includes a stop control circuit 55 that monitors an LED current and that stops a drive circuit 54 for driving a switch SW51 of the stepping-down chopper circuit 53 when the LED voltage becomes substantially zero.

[0006] Then, the above-mentioned conventional LED power source device 50 includes a mask circuit 56 for monitoring a voltage of the smoothing circuit 51 and for controlling the stop control circuit 55 so as not to operate in a period from turning-on of the power source to a predetermined time, from a point T_{51} in Fig. 5 to a point T_{52} in Fig. 5.
In the above-mentioned conventional LED power source device 50, at the point T52 in Fig. 5, the mask circuit 56 operates so that the stop control circuit 55 can start to operate when a voltage of the smoothing circuit 51 becomes a predetermined voltage or more.
Additionally, in the above-mentioned conventional LED power source device 50, the mask circuit 56 operates at a point T_{54} after a point T_{53} in Fig. 5 so that the stop control circuit 55 cannot operate in the case where a voltage of the smoothing circuit 51 becomes a predetermined voltage or less.

[0007] When the power source is turned on under a state where the LED 52 is connected, in the above-mentioned conventional LED power source device 50, the smoothed voltage due to the smoothing circuit 51 exceeds a predetermined voltage of the mask circuit 56 immediately after the power source is turned on at the point T_{52} after the point T_{51} in Fig. 5.
For this reason, the above-mentioned conventional LED power source device 50 controls the stop control circuit 55 for stopping the drive circuit 54 of the stepping-down chopper circuit 53 so as not to operate in a case of detecting an unloaded state.
Then, when the unloaded state is detected at a point T_{58} in Fig. 5 after a predetermined time passed, the above-mentioned conventional LED power source device 50 stops the drive circuit 54 of the stepping-down chopper circuit 53due to the stop control circuit 55, and thereby preventing the stepping-down chopper output from rising beyond necessity.

[0008] Meanwhile, in the above-mentioned conventional LED power source device 50, the power source is turned off under a state where the LED 52 is connected at a point T_{60} in Fig. 6 after a point T_{59} in Fig. 5.
Then, in the above-mentioned conventional LED power source device 50, the smoothed voltage of the smoothing circuit 51 is gradually decreased due to consumption of the LED 52 after the power source is turned off at the point T_{60} in Fig. 5.
For this reason, in the above-mentioned conventional LED power source device 50, when the smoothed voltage becomes a predetermined voltage of the mask circuit

56 or less at a point T_{61} in Fig. 5, the mask circuit 56 prohibits the operation of the stop control circuit 55.

In this manner, the above-mentioned conventional LED power source device 50 cannot operate the unloaded state detection performed by the stop control circuit 55; however, the stepping-down chopper circuit 53 still operates and the LED 52 consumes the power, and thus the smoothed voltage is decreased in a relatively-short time after the turning-off of the power source.

[0009] However, when the LED 52 is detached and attached under the state where the power source is applied, the above-mentioned conventional LED power source device 50 does not automatically recover the lighting of the LED because not having a circuit for recognizing the reattachment of the LED 52, and thereby maintaining a state where the stop control circuit 55 stops the drive circuit 54.

Since the drive circuit 54 continues to be stopped in the case where the power source is turned off under the state, the consumption of the smoothed voltage is reduced, and the above-mentioned conventional LED power source device 50 is discharged more gradually in comparison with the case where the LED 52 is attached.

[0010] Here, in the above-mentioned conventional LED power source device 50, when the smoothed voltage becomes the predetermined voltage of the mask circuit 56 or less, the mask circuit 56 operates so that the stop control circuit 55 cannot operate, and thus the stopped drive circuit 54 starts to operate again.

For this reason, in the above-mentioned conventional LED power source device 50, the stepping-down chopper circuit 53 operates due to the operation of the drive circuit 54, and thus a rated current or more flows to the LED 52.

Accordingly, in the above-mentioned conventional LED power source device 50, there is a possibility that the LED 52 is damaged.

[0011] This is because the above-mentioned conventional LED power source device 50 sets the predetermined voltage to be higher than a voltage at which the drive circuit 54 operates so that the mask circuit 56 cannot malfunction at an instantaneous falling and an instantaneous stopping of the voltage of the power source.

Accordingly, in the above-mentioned conventional LED power source device 50, that is effective means adapted to invalidate the judgment of the loaded state or the unloaded state due to the stop control circuit 55 to avoid the malfunction during the operation of the mask circuit 56.

However, in the above-mentioned conventional LED power source device 50, the longer a suppression time of the stop control circuit due to the mask circuit 56 becomes, the more timing at which the stop control circuit 55 functions delays.

[0012] Then, in the above-mentioned conventional LED power source device 50, when the LED 52 is detached and attached during the time, the stepping-down chopper circuit 53 does not stop, and thus a voltage higher than the total forward direction voltage of the LED 52 is charged to the capacitor C52 on an output side.

Accordingly, in above-mentioned conventional LED power source device 50, an excessive current flows in attaching the LED 52, thereby causing a possibility that the LED 52 is damaged.

[0013] Additionally, in the above-mentioned conventional LED power source device 50, after the power source is turned off, a voltage of a smoothing capacitor C51 of the power source exceeds an operational threshold value of the drive circuit 54 in a period when the mask circuit 56 is turned off.

Then, the above-mentioned conventional LED power source device 50 cannot maintain the stopping performed by the stop control circuit 55, and consequently starts an oscillation due to the drive circuit 54 again.

On this occasion, in the above-mentioned conventional LED power source device 50, since the stop control circuit 55 does not operate, the excessive current flows to the LED 52 even in the short period.

[0014] Thus, the above-mentioned conventional LED power source device 50 can avoid the phenomenon by extending a retention time after turning-off of the power source.

However, when the LED 52 is detached and attached during the operation of the mask circuit 54, the above-mentioned conventional LED power source device 50 easily generates the excessive current.

[0015] Accordingly, in the case where the LED 52 is detached and attached under the state where the voltage of the power source is applied, in the above-mentioned conventional LED power source device 50, the stop control circuit 55 operates under a state where the voltage of the smoothing power source is retained.

Then, in the above-mentioned conventional LED power source device 50, the mask circuit 56 starts to operate again at timing when the voltage lowers the operational threshold value of the mask circuit 56 after the turning-off of the power source.

For this reason, in the above-mentioned conventional LED power source device 50, the output of the stop control circuit 55 is prohibited, the drive circuit 54 starts due to a remaining component of the smoothed voltage, and thus the excessive current flows to the LED 52.

[0016] The present invention is achieved to solve the above-mentioned problem, and the purpose is to provide an LED power source device able to prevent an excessive current to an LED.

[Means adapted to solve the Problems]

[0017] An LED power source device according to the present invention includes: a rectifier for rectifying an alternating-current power source; an output power source adjustment circuit including a switch element for supplying an electric power to an LED; a drive circuit for driving the switch element; a stop control circuit for judging existence and nonexistence of the LED by detecting an electric current flowing to the LED and for operating to stop the drive circuit upon detection of the nonexistence of the LED; and a mask circuit for monitoring the voltage after the rectification to control the stop control circuit, wherein in the case where the voltage after the rectification is a predetermined value or less of the mask circuit, the operation of the stop control circuit is not prohibited.

[0018] In the LED power source device according to the present invention, the mask circuit outputs a stop signal to the drive circuit for driving the switching element in the case where the voltage is a predetermined threshold value or less.

[0019] The LED power source device according to the present invention, includes: a smoothing circuit for smoothing a rectified full-wave rectification voltage to be substantially constant; a stepping-down chopper circuit for operating to draw desired power from the LED; output smoothing circuit for smoothing a voltage drawn from the stepping-down chopper circuit; and a timer circuit in the stop control circuit, wherein the mask circuit continues to output a stop signal to the drive circuit even when the smoothed voltage becomes a predetermined value or less, and includes a discharge circuit connected to the smoothing circuit for operating to draw the smoothed power source.

[Effect of the Invention]

[0020] According to an LED power source device of the present invention, an effect that can prevent the excessive current to an LED can be obtained.

[Brief Description of the Drawings]

[0021]

[Fig. 1] Fig. 1 is a block configuration view of an LED power source device according to a first embodiment of the present invention.
[Fig. 2] Fig. 2 is a block configuration view of an LED power source device according to a second embodiment of the present invention.
[Fig. 3] Fig. 3 is a block configuration view of an LED power source device according to a third embodiment of the present invention.
[Fig. 4] Fig. 4 is a block configuration view of a conventional LED power source device.
[Fig. 5] Fig. 5 is a timing chart of the conventional LED power source device.

[Best Mode for Carrying Out the Invention]

[0022] Referring to drawings, LED power source devices according to embodiments of the present invention will be explained below.

(First embodiment)

[0023] As shown in Fig. 1, an LED power source device 10 according to a first embodiment of the present invention has: a rectifier DB that is a diode bridge for rectifying an alternating-current power source; and a smoothing circuit 11 for smoothing a rectified full-wave rectification voltage to be substantially constant.

[0024] The LED power source device 10 includes a switch element SW1, and has: a stepping-down chopper circuit 13 that is an output power source adjustment circuit operating so as to draw desired power from an LED 12 serving as a load; and a drive circuit 14 for driving the switching element SW1.

[0025] The LED power source device 10 has: an output smoothing circuit 15 for smoothing the voltage drawn from the stepping-down chopper circuit 13; and a stop control circuit 16 that operates so as to stop the drive circuit 14 upon detection of a state where there is not the LED 12.

[0026] The LED power source device 10 has a master circuit 17 for controlling the stop control circuit 16 by monitoring a voltage after the rectification.

[0027] The smoothing circuit 11 includes a smoothing capacitor C1.
The mask circuit 17 has: a switching element Q1 that is an NPN-type transistor; a switching element Q2 that is the NPN-type transistor; and a switching element Q3 that is the NPN-type transistor.
The mask circuit 17 includes: a capacitor C2; a capacitor C3; an electrolytic capacitor C4; a Zener diode ZD1; a resistance R1; a resistance R2; a resistance R3; a resistance R4; a resistance R7; and a resistance R8.

[0028] The switch element SW1 blocks an electric power to an inductor L1 included in the stop control circuit 16 due to driving of the drive circuit 14.
The stepping down chopper circuit 13 includes: the switch element SW1; the inductor L1; and a diode D4.

[0029] The drive circuit 14 is connected to a collector of the switching element Q3 included in the stop control circuit 16.
The output smoothing circuit 15 includes: a smoothing capacitor C5; and a resistance R9.
The output smoothing circuit 15 is connected to the LED 12 at the output.
The stop control circuit 16 includes: the switching element Q3 that is the NPN-type transistor; and a switching element Q4 that is the NPN-type transistor.

[0030] Next, an operation of the LED power source device 10 will be explained.
After the power source is turned on, when a voltage exceeds a threshold value of the mask circuit 17, the switching element Q1 is turned on. Due to the turning-on of the switching element Q1, the switching element Q2 is turned off.
Accordingly, a base current is not provided to the switching element Q3 due to the turning-off of the switching element Q2, and thus the switching element Q4 is turned off.

[0031] Then, the switching element Q3 is turned on due to the turning-off of the switching element Q4, and thus the drive circuit 14 is stopped.

On this occasion, the operation starts under a condition over a threshold value of a first timer circuit 18 including the switching element Q5 having a bigger time constant than a time constant configured as a base of the switching element Q1.

For this reason, under the state where the power source voltage is applied, the switching element Q1 is constantly turned on by supply of the base current from the switching element Q5.

[0032] Meanwhile, even when the power source is turned off under a state where the LED 12 is connected, the switching element Q4 is turned on, and accordingly the drive circuit 14 is not stopped by the switching element Q3. Then, since the drive circuit 14 continues to operate until reaching an operational threshold value, the smoothed voltage that is already smoothed falls relatively fast, and the drive circuit 14 stops to operate.

In this manner, the LED power source device 10 detects the turning-off of the power source without depending on existence and nonexistence of the LED 12 and on the operational state of the stop control circuit 16, and blocks a signal supplied from the output smoothing circuit 15 to the mask circuit 17.

[0033] In the case where the LED 12 is detached and attached under the state where the power source is turned on, even when the voltage lowers a predetermined value of the mask circuit 17, the switching element Q5 having the big time constant continues to be turned on.

For this reason, the switching element Q1 is not turned on, and accordingly the base current of the switching element Q3 of the stop control circuit 16 is not drawn by the switching element Q2.

In this manner, even when the voltage lowers the predetermined value of the mask circuit 17, the stopping state of the drive circuit 14 can be retained until the smoothed voltage becomes the operational threshold value of the drive circuit 14 or less.

Accordingly, it can be prevented to restart the stepping-down chopper circuit 13 and consequently to supply the excessive current to the LED 12.

[0034] Meanwhile, in the LED power source device 10 according to the first embodiment, the switching element Q5 is configured by using a transistor.

However, if realizing that the turning-on of the switching element Q1 can be maintained in the case where the smoothed voltage is the operational threshold of the drive circuit 14 or more, any configuration can be employed.

In this manner, even when the LED 12 is detached and attached under the state of the power source is turned on, the drive circuit 14 does not start again, and thus it can be prevented to apply the excessive current to the LED 12.

Additionally, in the LED power source device 10 according to the first embodiment, the turning-on of the switching element Q1 is maintained; however, a configuration where the switching element Q2 is turned off at the application of the excessive current to the LED 12 can prevent the application of the excessive current in the same manner.

Moreover, in the LED power source device 10 according to the first embodiment, the transistors are employed for the stop control circuit 16, the mask circuit 17, and the first timer circuit 18; however, if an electric component having a switching element, a MOSFET, a microcomputer, and the like also can be employed other than the transistor.

[0035] As described above, the LED power source device 10 according to the first embodiment can detect existence and nonexistence of the LED 12 and stop the oscillation of the stepping-down chopper circuit 13 when in the unloaded state, thereby preventing the excessive current flowing to the LED 12 in re-attachment of the LED 12.

In addition, when the LED 12 is detached and attached under the state where the turning-on of the power source is maintained, the state being assumed in a trouble and the like of the LED 12, the LED power source device 10 according to the first embodiment can stop the operation of the stepping-down chopper circuit 13, thereby preventing the excessive current to the LED 12.

[0036] Then, the LED power source device 10 according to the first embodiment can prevent the excessive current of the LED 12 without using an expensive electronic component such as the microcomputer, thereby being manufactured in a low cost.

(Second embodiment)

[0037] Next, an LED power source device according to a second embodiment of the present invention will be explained.

Meanwhile, in embodiments described below, explanations of: the same components as those of the above-mentioned first embodiment and the functionally-same components will be simplified or omitted by adding the same numeral or the equivalent numeral in the drawing.

[0038] As shown in Fig. 2, an LED power source device 20 according to the second embodiment of the present embodiment has a control circuit 21 for outputting a stop signal to stop the drive circuit 14 without regard to the states of the mask circuit 17 and the stop control circuit 16 in the case where a smoothed voltage becomes a predetermined value or less of the mask circuit 17.

[0039] The control circuit 21 includes: a diode D1; and a diode D2.

The diode D1 is connected the collector of the switching element Q2 at the cathode, and is connected to the drive circuit 14 at the anode.

The diode D2 is connected to the collector of the switching element Q2 at the cathode, and is connected to the collector of the switching element Q4 of the stop control circuit 16.

[0040] Next, an operation of the LED power source device 20 will be explained.

When the power source is turned on under the state where the LED 12 is connected, the mask circuit 17 starts to operate before the smoothed voltage smoothed by the smoothing circuit 11 rises to the operational threshold value of the drive circuit 14.

Accordingly, after a predetermined time passed, the switching element Q1 is turned on from off, and the switching element Q2 is turned off from on.

In this manner, the LED 12 continues to be lighted, and the stop control circuit 16 stops the operation until the LED 12 is detached.

[0041] When the power source is turned off under the state where the LED 12 is connected, until the smoothed voltage falls to the predetermined value of the mask circuit 17, the switching element Q1 continues to be turned on, and the switching element Q2 continues to be turned off.

For this reason, since the drive circuit 14 operates up to the operational threshold value of the drive circuit 14, the smoothed voltage rapidly falls because consumed, and becomes the predetermined value or less of the mask circuit 17.

In this manner, the switching element Q1 is turned off, the switching element Q2 is turned on, and thus a base current of the switching element Q3 is blocked.

However, the base current of the switching element Q3 is generated through the diode D1 of the control circuit D1 of the control circuit 21, thereby stopping the drive circuit 14.

[0042] Meanwhile, in the case where the LED 12 is detached and attached under the state where the turning-on of the power source is maintained, the stop control circuit 16 operates at the timing when the LED 12 is detached, and the drive circuit 14 continues to be stopped.

After that, when the power source is turned off, the drive circuit 14 continues to be stopped, the consumption of the LED 12 does not occur, and accordingly the smoothed voltage gradually falls to the predetermined value of the mask circuit 14.

Then, when the smoothed voltage becomes the predetermined value or less, the switching element Q1 is turned off, and the switching element Q2 is turned on.

However, the drive circuit 14 is stopped by the turning-on of the switching element Q2 via the diode D1.

Accordingly, even when the smoothed voltage falls below the predetermined value of the mask circuit 17 and the mask circuit 17 is reset, the drive circuit 14 starts again, thereby preventing the excessive current to the LED 12.

[0043] According to the LED power source device 20 of the second embodiment, when being the predetermined value or less, the mask circuit 17 outputs the stop signal to the drive circuit 14 for driving the switch circuit SW1.

In addition, according to the LED power source device 20 of the second embodiment, existence and nonexistence of the LED 12 is detected, the oscillation of the stepping-down chopper 13 is stopped when in the unloaded state, thereby preventing the excessive current flowing to the LED 12 in re-attachment of the LED 12.

And, even in the case where the LED 12 is detached and attached under the state where the turning-on of the power source is maintained, the state being assumed in a trouble and the like of the LED 12, the LED power source device 20 according to the second embodiment can stop the operation of the stepping-down chopper circuit 13, thereby preventing the excessive current to the LED 12.

[0044] Then, since the control circuit 21 includes the diode D1 and diode D2, which are low-cost elements, the LED power source device 20 of the second embodiment can be manufactured advantageously in the costs.

(Third embodiment)

[0045] Next, an LED power source device according to a third embodiment of the present invention will be explained.

As shown in Fig. 3, an LED power source device 30 according to the third embodiment of the present invention has a second timer circuit 31 including: the switching element Q5; an electrolytic capacitor C6; and the diode D3.

In the LED power source device 30, the mask circuit 17 continues to output a stop signal to the drive circuit 14 even when a smoothed voltage becomes a predetermined value, and a discharge circuit 32 connected to the smoothing circuit 11 operating so as to draw the smoothed power source is included.

The discharge circuit 32 includes: a resistance R11; and the switching element Q6 that is a PNP-type transistor.

[0046] Next, an operation of the LED power source device 30 will be explained.

In the LED power source device 30, the case where the power source is turned off after the LED 12 is detached and attached under a condition where the power source is kept to be turned on is considered.

The second timer circuit 31 charges the electrolytic capacitor C6 during the operation of the stop control circuit 16.

After the turning-off of the power source, the smoothed voltage gradually decreases, and accordingly even if the switching element Q2 is tried to be turned on under the condition where the switching element Q1 of the mask circuit 17 is turned off, the base current of the switching element Q2 is already drawn by the switching element Q6.

Thus, the switching element cannot be turned on, and does not stop the stop control circuit 16.

[0047] When the switching element Q2 is turned on after a predetermined time determined by the second timer circuit 31 has passed, the base current is provided to the switching element Q6, and accordingly the discharge circuit 32 operates. For this reason, a smoothed power source of the stepping-down chopper circuit 13 can be rapidly decreased and can be set to the operational threshold value of the drive circuit 14 in a short time, and accordingly the re-starting of the stepping-down chopper circuit 13 due to the drive circuit 14 can be prevented, thereby preventing the excessive current to the LED 12.

[0048] According to the LED power source device 30 of the third embodiment, when the switching element Q2 is turned on after the predetermined time determined by the second timer circuit 31 has passed, the discharge circuit 32 operates.

Then, according to the LED power source device 30 of the third embodiment, the smoothed power source of the stepping-down chopper circuit 13 can be rapidly decreased and can be set to the operational threshold value or less of the drive circuit in a short time.

Thus, according to the LED power source device 30 of the third embodiment, the re-starting of the stepping-down chopper circuit 13 due to the drive circuit 14 can be prevented, thereby preventing the excessive current to the LED 12.

[0049] Meanwhile, in the LED power source device of the present invention, the rectifier, the smoothing circuit, and the like are not limited to those of the above-described embodiments, and can be arbitrarily modified and improved.

[Description of Reference Numerals]

[0050]

10, 20, 30	LED power source device
11	Smoothing circuit
12	LED (load)
13	Stepping-down chopper circuit (Output power source adjustment circuit)
14	Drive circuit
15	Output smoothing circuit
16	Stop control circuit
17	Mask circuit
31	Second timer circuit (Timer circuit)
32	Discharge circuit
DB	Diode bridge (Rectifier)
SW1	Switch element

Claims

1. An LED power source device comprising:

a rectifier for rectifying an alternating-current power source;
an output power source adjustment circuit including a switch element for supplying an electric power to an LED;
a drive circuit for driving the switch element;
a stop control circuit for judging existence and nonexistence of the LED by detecting an electric current flowing to the LED and for operating to stop the drive circuit upon detection of the nonexistence of the LED; and
a mask circuit for monitoring the voltage after the rectification to control the stop control circuit, wherein
in the case where the voltage after the rectification is a predetermined value or less of the mask circuit, the operation of the stop control circuit is not prohibited.

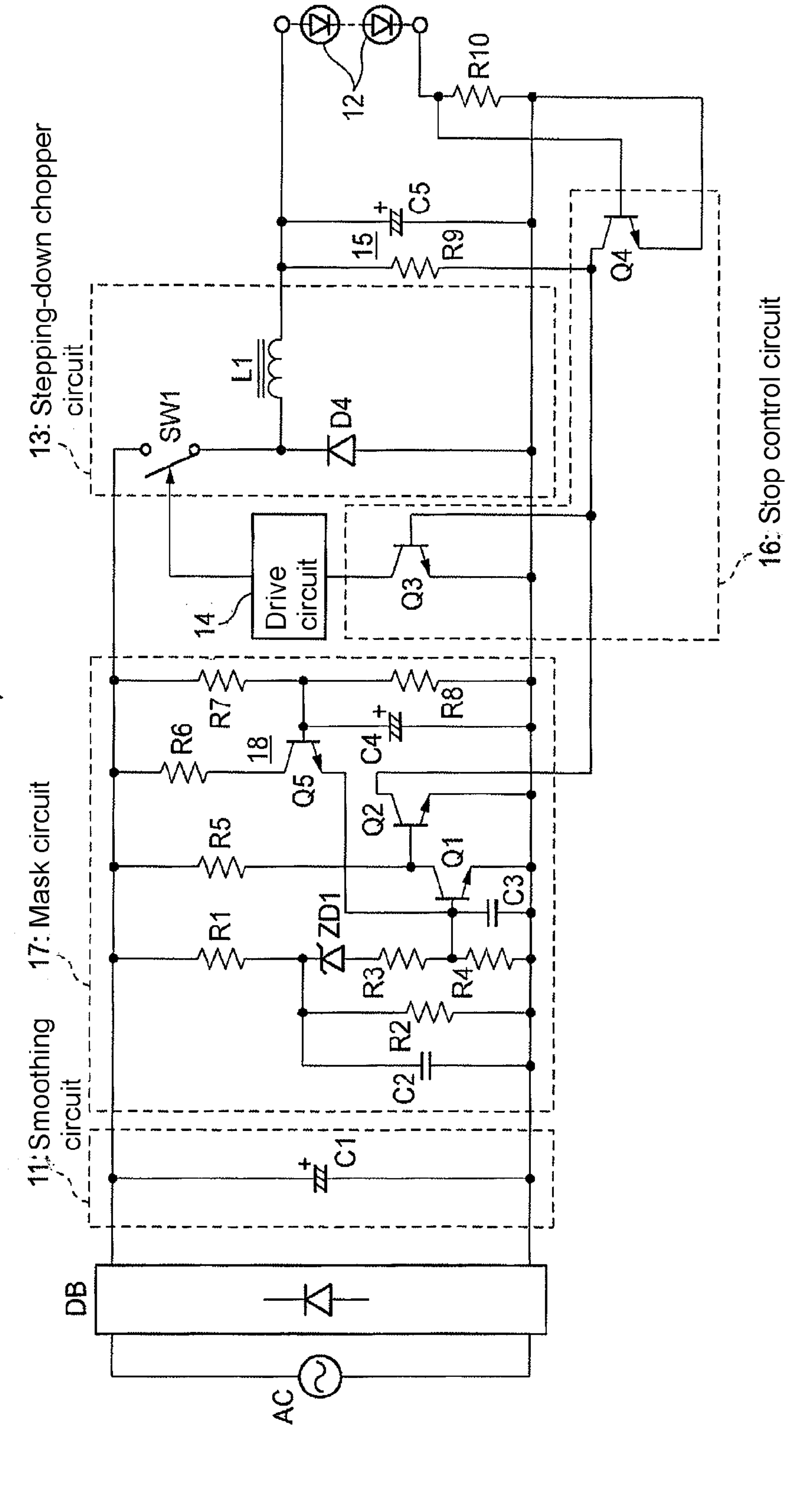
2. The LED power source device according to claim 1, wherein
the mask circuit outputs a stop signal to the drive circuit for driving the switching element in the case where the voltage is a predetermined threshold value or less.

3. The LED power source device according to claim 1 or claim 2, comprising:

a smoothing circuit for smoothing a rectified full-wave rectification voltage to be substantially constant;
a stepping-down chopper circuit for operating to draw desired power from the LED; and
an output smoothing circuit for smoothing a voltage drawn from the stepping-down chopper circuit; and including:

a timer circuit in the stop control circuit, wherein
the mask circuit continues to output a stop signal to the drive circuit even when the smoothed voltage becomes a predetermined value or less, and includes a discharge circuit connected to the smoothing circuit for operating to draw the smoothed power source.

Fig. 1



10
12
R10
C5
15
R9
Q4
13: Stepping-down chopper circuit
SW1
L1
D4
Drive circuit
14
Q3
16: Stop control circuit
R6
R7
R8
C4
18
Q5
Q2
R5
Q1
C3
17: Mask circuit
R1
ZD1
R3
R4
R2
C2
11: Smoothing circuit
C1
DB
AC

Fig. 2

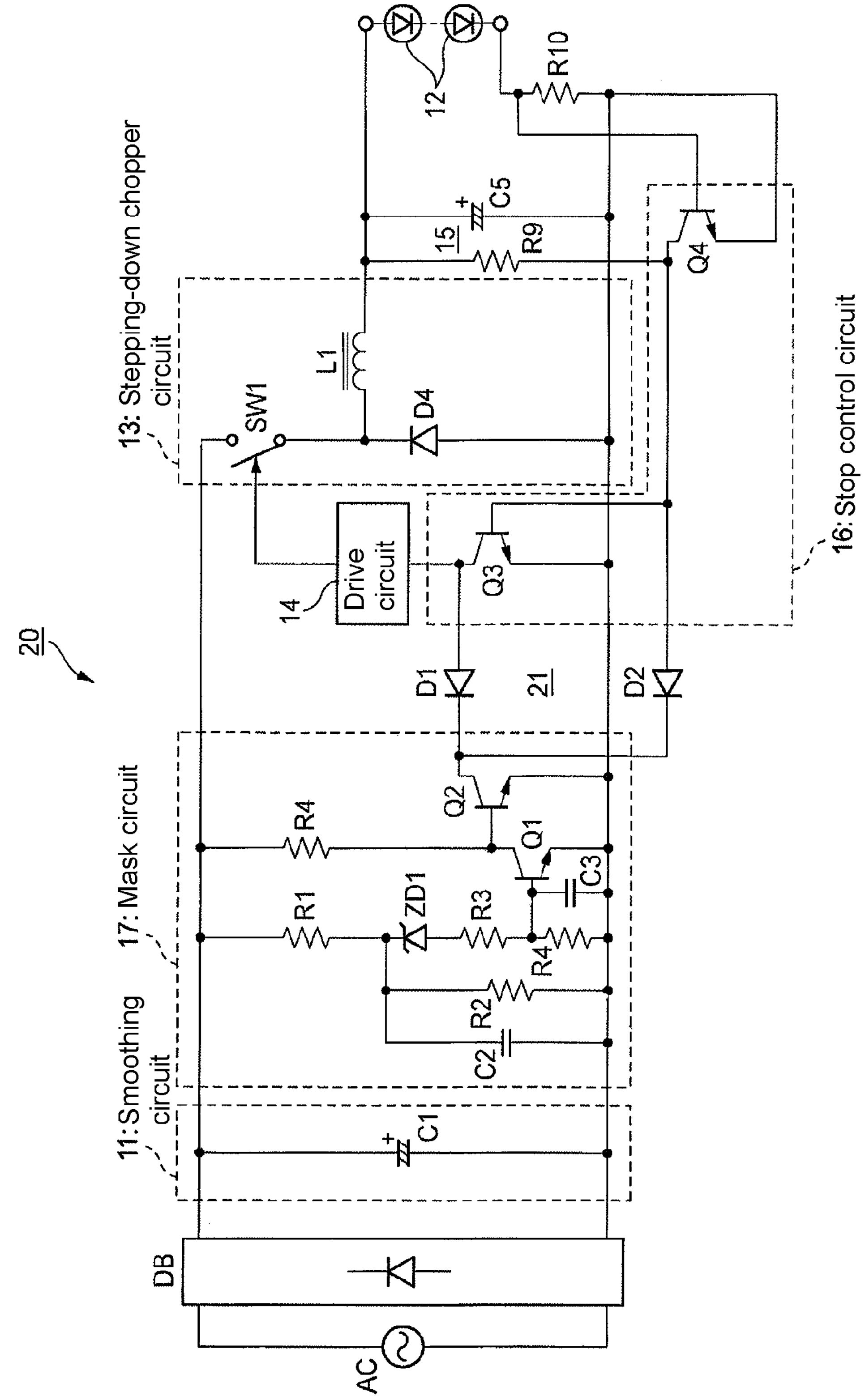

13: Stepping-down chopper circuit
SW1
L1
D4
15
C5
R9
R10
12
Q4
16: Stop control circuit
Drive circuit
14
Q3
20
D1
21
D2
17: Mask circuit
R4
Q2
Q1
R1
ZD1
R3
C3
R4
R2
C2
11: Smoothing circuit
C1
DB
AC

Fig. 3

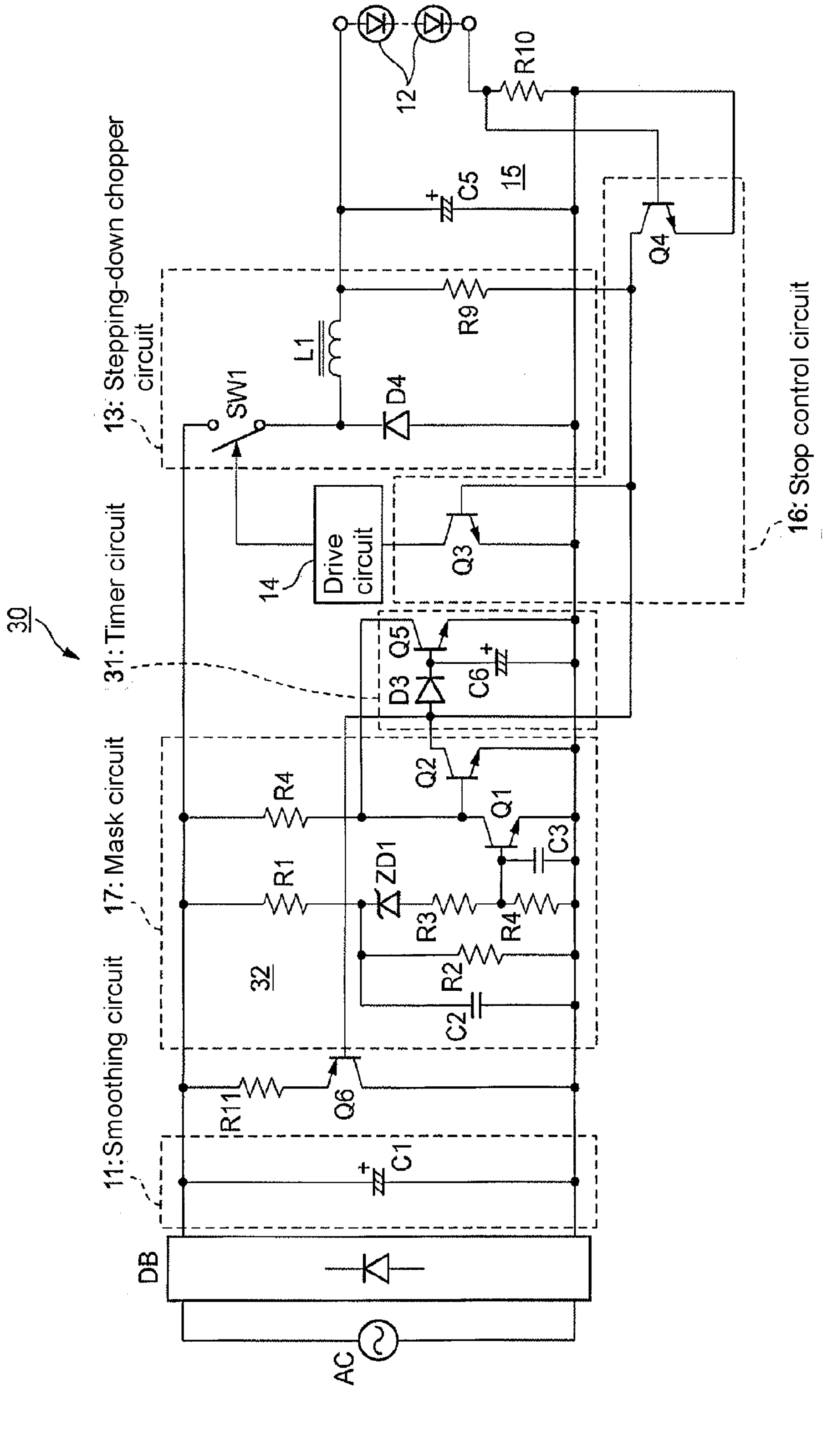
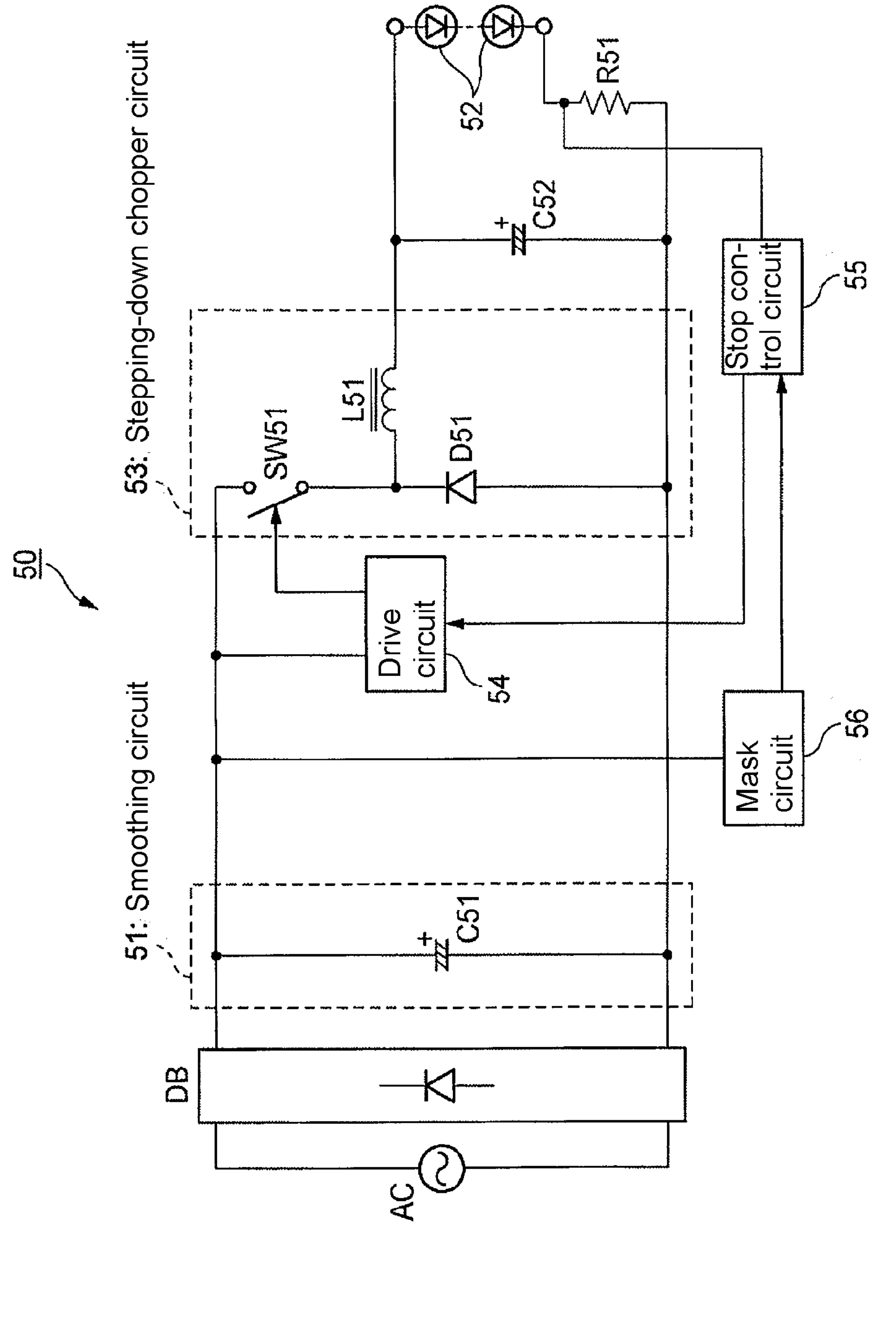
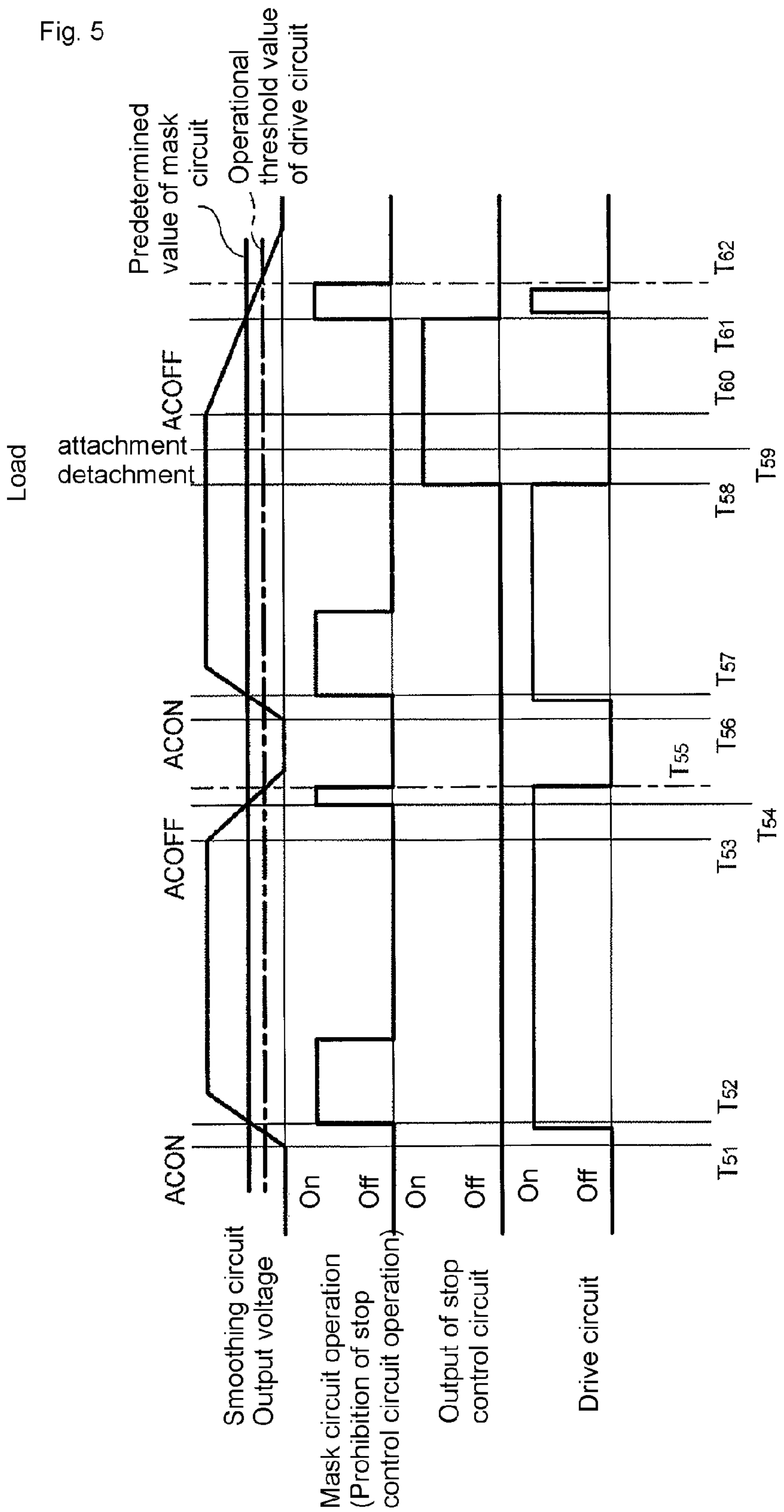

30
11:Smoothing circuit
13: Stepping-down chopper circuit
14
15
16: Stop control circuit
17: Mask circuit
31: Timer circuit
32
12
Drive circuit
AC
DB
C1
C2
C3
C5
C6
R1
R2
R3
R4
R4
R9
R10
R11
ZD1
D3
D4
L1
SW1
Q1
Q2
Q3
Q4
Q5
Q6

Fig. 4



50
53: Stepping-down chopper circuit
51: Smoothing circuit
SW51
L51
D51
C52
C51
52
R51
DB
AC
Drive circuit
54
Stop control circuit
55
Mask circuit
56

Fig. 5


Load
attachment
detachment
Predetermined value of mask circuit
Operational threshold value of drive circuit
ACON
ACOFF
ACON
ACOFF
Smoothing circuit Output voltage
Mask circuit operation (Prohibition of stop control circuit operation)
Output of stop control circuit
Drive circuit
On
Off
On
Off
On
Off
T51
T52
T53
T54
T55
T56
T57
T58
T59
T60
T61
T62