

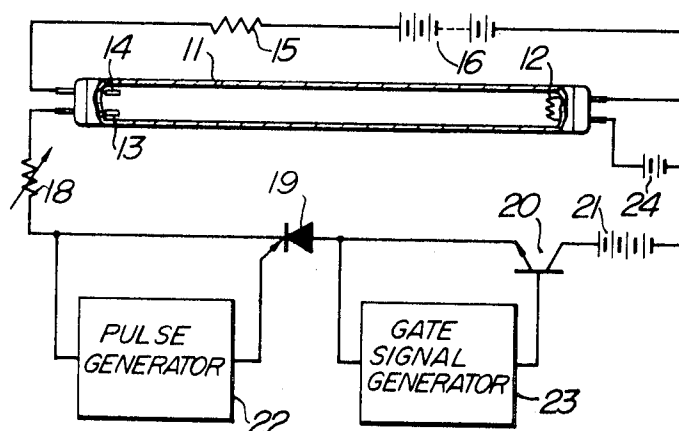
[72] Inventors **Hiromasa Nakatsu**
Tondabayashi-shi;
Takeshige Ichida, Kadoma-shi; Teruhisa
Kaneko, Kadoma-shi; Sadao Matsumoto,
Hirakata-shi; Tokuyuki Wakiyama,
Moriguchi-shi; Kenzi Murata, Kadoma-shi,
all of Japan
[21] Appl. No. **842,501**
[22] Filed **July 17, 1969**
[45] Patented **Oct. 5, 1971**
[73] Assignee **Matsushita Electric Industrial Co., Ltd.**
Osaka, Japan
[32] Priority **July 23, 1968, Aug. 14, 1968**
[33] **Japan**
[31] **43/52068 and 43/57913**

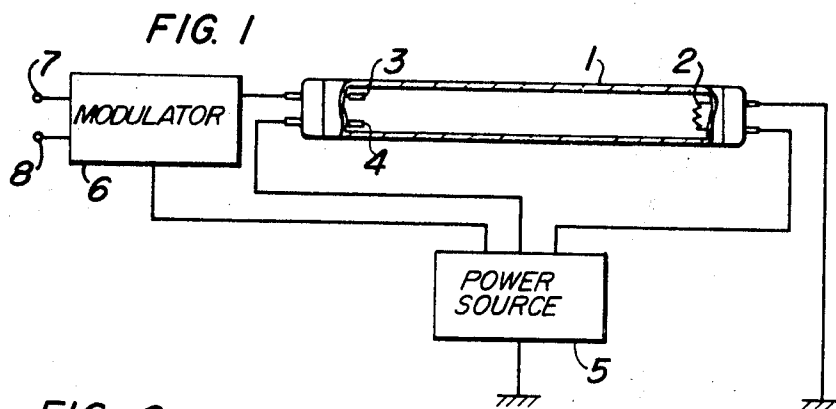
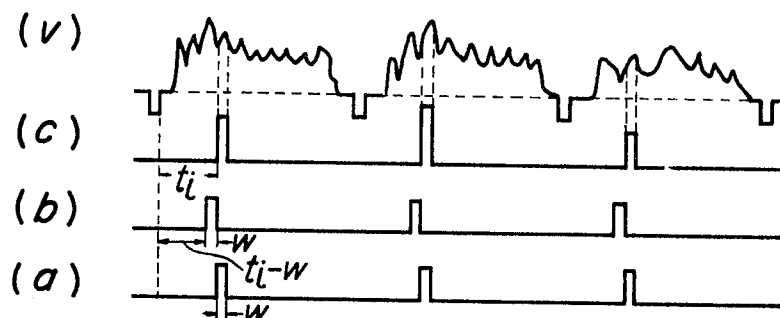
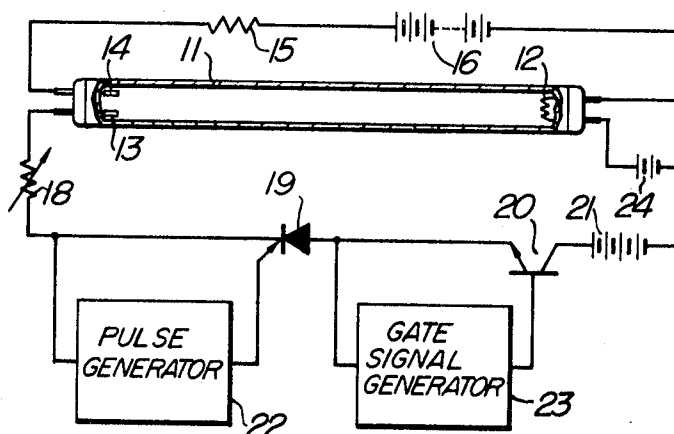
[56] **References Cited**
UNITED STATES PATENTS
1,899,021 2/1933 Druyvesteyn..... 315/337 X
2,972,707 2/1961 Wood..... 315/169 X
3,066,241 11/1962 Palmer 315/99
3,263,125 7/1966 Genuit..... 315/219
3,265,930 8/1966 Powell..... 315/289 X
3,471,747 10/1969 Getschen..... 315/205
FOREIGN PATENTS
953,004 3/1964 Great Britain..... 315/101
Primary Examiner—Roy Lake
Assistant Examiner—E. R. LaRoche
Attorney—Stevens, Davis, Miller & Mosher

[54] **SEMICONDUCTOR APPARATUS FOR**
CONTROLLING THE BRIGHTNESS OF A
DISCHARGE LAMP
5 Claims, 8 Drawing Figs.

[52] U.S. Cl..... **315/205,**
313/188, 315/168, 315/172, 315/207, 315/208,
315/224, 315/260, 315/335, 315/DIG. 1,
315/DIG. 4, 315/DIG. 7
[51] Int. Cl..... **H05b 41/30,**
H05b 41/392
[50] Field of Search..... **313/1, 3,**
109, 188; 315/64, 69, 98, 101, 94, 99, 102, 103,
105, 200, 202, 206, 208, 219, 221, 260, 160, 167,
168, 169, 171, 172, 175, 176, 205, 224, 330, 335,
337, 100 H, 100 V, 100 T

ABSTRACT: A fluorescent lamp lighting apparatus which comprises a DC fluorescent discharge lamp having one hot negative electrode and two positive electrodes, a first DC source for constantly generating a glow discharge between said negative electrode and one of said positive electrodes, a second DC source for generating an arc discharge between said negative electrode and another one of said positive electrodes, and semiconductor control means for intermittently interrupting the power supply from said second DC source to the discharge lamp and controlling the magnitude of its voltage, said semiconductor control means being used for on-off control of the fluorescent discharge lamp and for brilliance modulation of the same in response to a video signal of a television signal; and which enables the blinking frequency of the fluorescent discharge lamp to be reduced to several tens of microseconds to several hundreds of microseconds and can be used as a light source for display apparatus.



**FIG. 2****FIG. 3**

H. NAKATSU, T. ICHIDA, T. KANEKO, S. MATSUMOTO,
T. WAKIYAMA AND K. MURATA

INVENTORS

BY *Stevens, Davis, Miller & Mosher*
ATTORNEYS

FIG. 4

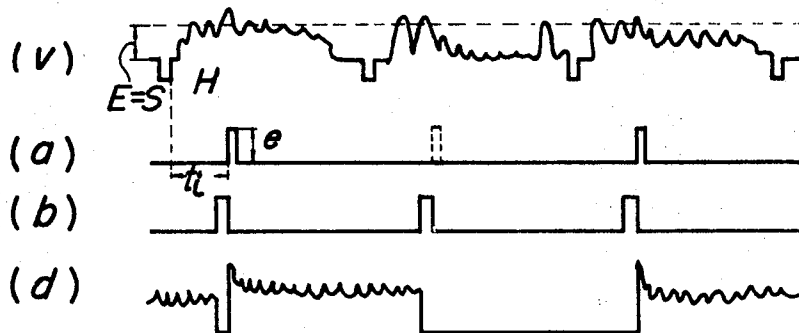


FIG. 5

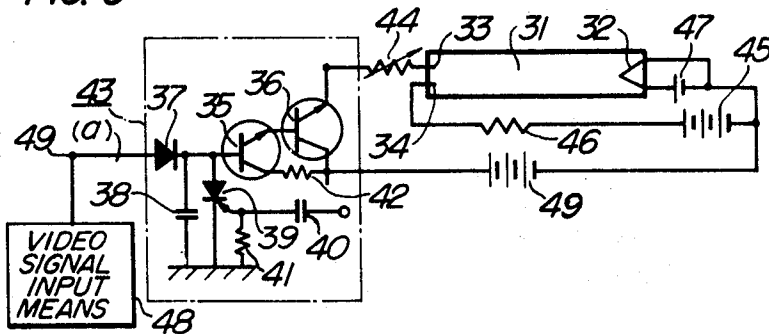


FIG. 6

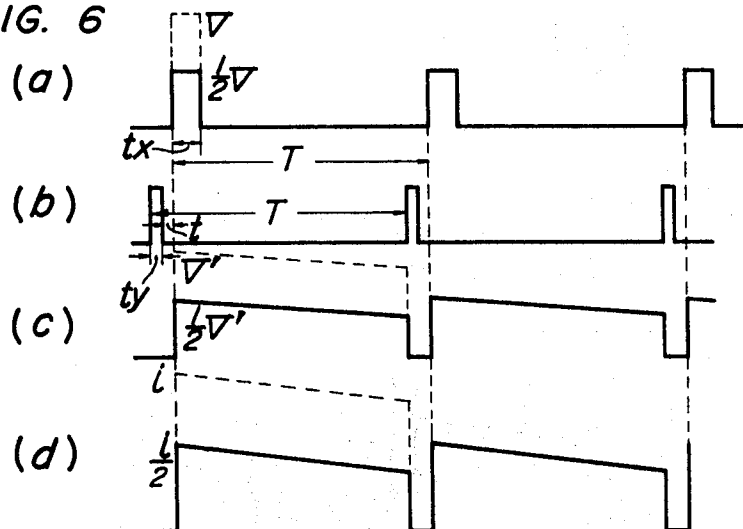


FIG. 7

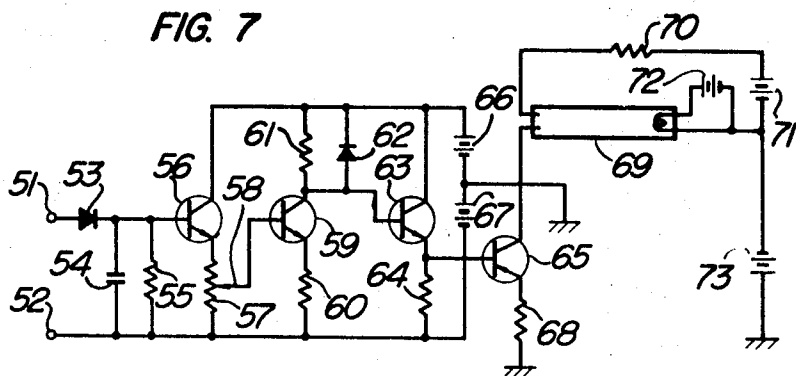
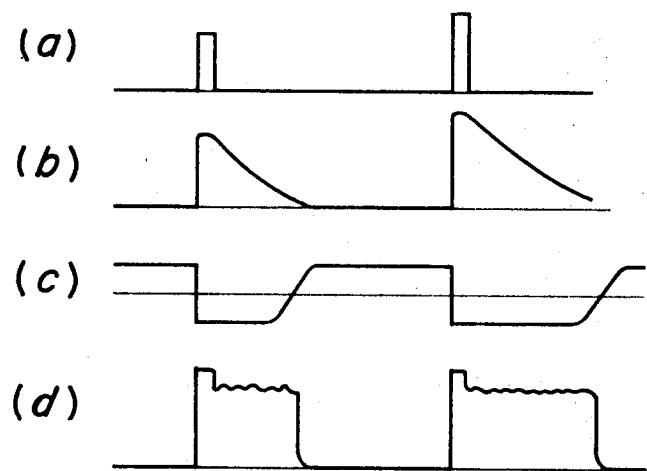


FIG. 8



SEMICONDUCTOR APPARATUS FOR CONTROLLING THE BRIGHTNESS OF A DISCHARGE LAMP

The present invention relates to lighting apparatus for discharge lamps, and more particularly to lighting apparatus which provides instantaneous activation and easy brilliance modulation of a fluorescent discharge lamp.

In the past, various systems for the instantaneous activation of a discharge lamp, particularly of a fluorescent discharge lamp, have been developed and put in practical use. However, any one of these conventional systems requires a period of several seconds to several hundreds milliseconds for activating an associated lamp. Further, for adjusting the brightness of a discharge lamp of the type described, an apparatus comprising a transistor or a silicon-controlled rectifier has been used but such apparatus has the disadvantage that the brightness cannot be changed at high speed. It is for this reason that discharge lamps are not being used as light sources for display apparatus, including advertising apparatus.

The primary object of the present invention is to provide lighting apparatus which is capable of controlling the brilliance of a discharge lamp intermittently at high speed.

Another object of the present invention is to provide a light source unit for large-size display apparatus including outdoor advertisements.

According to the present invention, use is made of a discharge lamp provided with one hot negative electrode and two positive electrodes. An abnormal glow discharge, or an extremely mild discharge is generated between said hot negative electrode and one of said positive electrodes to maintain part of the gaseous interior of the tube ionized, whereby the activation time of the lamp can be reduced to as little as about several microseconds to provide for instantaneous activation, and further the discharge current or the lighting time can be controlled each time the lamp is activated.

Other objects, features and advantages of the present invention will become apparent from the following detailed description when taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a diagram showing the construction of an apparatus embodying the principle of the present invention;

FIG. 2 is an operational waveform diagram of the apparatus;

FIG. 3 is a diagram showing one form of the circuit arrangement of the apparatus according to the invention;

FIG. 4 is an operational waveform diagram of the apparatus shown in FIG. 3;

FIG. 5 is a diagram showing another form of the circuit arrangement of the apparatus according to the invention;

FIG. 6 is an operational waveform diagram of the apparatus shown in FIG. 5;

FIG. 7 is a diagram showing still another form of the circuit arrangement of the apparatus according to the invention; and

FIG. 8 is an operational waveform diagram of the apparatus shown in FIG. 7.

Referring first to FIG. 1 in which is shown the basic layout of the apparatus according to the present invention, a discharge lamp 1, e.g. a fluorescent lamp, has a coil-shaped hot negative electrode 2 at one end and two positive electrodes, i.e. a main positive electrode 3 and an auxiliary positive electrode 4, at the other end thereof. From a power source 5 a heating current is supplied to the hot negative electrode 2 of the fluorescent lamp 1, and also a direct-current voltage is impressed across said hot negative electrode 2 and the auxiliary positive electrode 3 to generate an abnormal glow discharge therebetween. In addition, the power source 5 impresses a direct-current voltage across the hot negative electrode 2 and the main positive electrode 3 through brilliance modulating circuit 6 to generate an arc discharge between said electrodes 2 and 3. The brilliance modulating circuit 6 resets the fluorescent lamp 1 in response to a signal from a terminal 7, and also turns said fluorescent lamp on and modulates the brilliance thereof in response to a signal from a terminal 8.

The operation of the apparatus constructed as described above will be explained with reference to FIG. 2. On the terminals 7 and 8 of the brilliance modulating circuit 6 are impressed an input signal (a) and an input signal (b) respectively. The signal (a) is obtained by sliding a signal (c) based on a predetermined amplitude, which signal (c) is obtained by sampling the horizontal synchronizing pulse of a video signal (v) after passage of a time t_i . The signal (b) is impressed on the input terminal 8 of the brilliance modulating circuit 6 before the signal (a) is impressed on the terminal 7. The signal (b) is a wave form having a predetermined pulse width W at a point in time $(t_i - W)$ past the horizontal synchronizing pulse. The discharge lamp 1 is turned off upon receipt of the signal (b) and is turned on upon receipt of the signal (a), and the brilliance thereof is modulated by the height or width of the wave of the signal (a).

Prior to turning the fluorescent lamp 1 on, an abnormal glow discharge is generated across the hot negative electrode 2 and the auxiliary positive electrode 4 under the direct-current voltage supplied from the power source 5, so as to maintain part of the gaseous interior of said lamp ionized. Upon impressing the signal (a) across the hot negative electrode 2 and the main positive electrode 3 under such condition, an arc discharge is generated with a time delay of only several microseconds or less, and thus the discharge lamp 1 is turned on instantaneously. A signal supplied to the apparatus shown in FIG. 1 is not necessarily a video signal (v) but may be one having a large cycle of repetition.

One form of the practical circuit arrangement of the apparatus is shown in FIG. 3, which is designed for the blinking control of a fluorescent lamp. With reference to FIG. 3, reference numeral 11 designates a fluorescent lamp of a similar construction as that shown in FIG. 1, having a coil-shaped hot negative electrode 12, a main positive electrode 13 and an auxiliary positive electrode 14. Between the hot negative electrode 12 and the auxiliary positive electrode 14 are inserted in series an auxiliary discharge stabilizing resistor 15 and a direct-current power source for the auxiliary discharge. On the other hand, between the hot negative electrode 12 and the main positive electrode 13 are inserted in series a current controlling resistor 18, a unidirectional thyristor 19, e.g. a silicon-controlled rectifier, having a gate electrode, a switching transistor 20 and a direct-current power source 21, which form a main discharge circuit. A pulse generator 22 is connected between the gate and the cathode of the silicon-controlled rectifier 19 to control energization of said silicon-controlled rectifier. A gate signal generator 23 is provided to energize and deenergize the switching transistor 20. Reference numeral 24 designates a direct-current power source for heating the hot negative electrode 12 of the fluorescent lamp 11.

In the arrangement described above, a mild auxiliary discharge (abnormal glow discharge) is previously generated across the hot negative electrode 12 and the auxiliary positive electrode 14 of the fluorescent lamp 11 under a voltage from the direct-current power source 16. The discharge current in this case is controlled by the auxiliary discharge stabilizing resistor 15. The auxiliary discharge stabilizing resistor 15 is so high in its resistance value that a predetermined voltage only is impressed across the hot negative electrode 12 and the auxiliary positive electrode 14. The mercury vapor interior of the fluorescent lamp 11 is partially ionized by the mild auxiliary discharge generated across the auxiliary positive electrode 14 and the hot negative electrode 12. In this state, the switching transistor 20 is energized by the gate signal generator 23 and then the silicon controlled rectifier 19 is energized by said gate pulse generator 22, whereupon part of the voltage of the direct-current power source 21 is impressed across the main positive electrode 13 and the hot negative electrode 12 of the fluorescent lamp 11. In this case, since ionized ions and electrons are present in the interior of the tube of the fluorescent lamp 11, an arc discharge is immediately generated across the electrodes 12 and 13, and thus the fluorescent lamp 11 is

turned on. The brilliance of the fluorescent lamp 11 may be changed by controlling the discharge current upon adjusting the variable resistor 18.

When supply of the gate signal to the switching transistor 20 is interrupted for a short time, with the fluorescent lamp 11 turned on, the voltage across the anode and the cathode of the silicon-controlled rectifier 19 becomes zero, so that said silicon-controlled rectifier 19 restores its interrupting capacity and the state of interruption of the gate signal supply is maintained to keep the fluorescent lamp 11 in an off-position, even if the switching transistor 20 is energized thereafter. The silicon-controlled rectifier 19 is turned on and the fluorescent lamp 11 is turned on again as soon as the gate pulse is supplied to said silicon-controlled rectifier from the gate pulse generator 22.

As shown in FIG. 4, the pulse generator 22 for the silicon-controlled rectifier 19 slices a video signal (v) by a predetermined amplitude $E=S$ and samples it with a time delay ti from the horizontal synchronized pulse H , the sampling wave form being shown in FIG. 4(a). FIG. 4(b) shows the waveform of the pulse generated by the gate signal generator 23. Therefore, the current flowing from the main positive electrode 13 to the hot negative electrode 12 of the fluorescent lamp 11 is interrupted by the signal (b) as shown in FIG. 4(d) and is restored by the signal (a). Where the signal (b) is not followed by the signal (a), no current flows through the fluorescent lamp 11 and hence the fluorescent lamp is turned off.

As such, the fluorescent lamp 11 can be turned on and off at an interval of several tens of microseconds to several hundreds of microseconds, by continuously maintaining an abnormal glow discharge, and it is impossible at all for the human eye to visually recognize such blinking of the fluorescent lamp.

Therefore, when at least three of the fluorescent lamps, constructed as described above and designed to generate a red, green, blue and white chromatic colors respective, are combined into one unit, it is possible to obtain a variety of chromatic lights of different colors by selectively turning on and off these fluorescent lamps and mixing the chromatic lights, produced by the respective fluorescent lamps, with each other using a light diffusing reflector. Further, a display apparatus can be assembled with a plurality of such units, in which an image appearing on an image surface can be changed without allowing the viewer to recognize the blinking of the light sources or blinking of lights on said image surface. Incidentally, it will be obvious to those skilled in the art that the switching transistor 20 and the gate signal generator 23 may be replaced by other high-speed switching means.

By employing the apparatus according to the present invention, the high-speed blinking of a fluorescent lamp becomes possible which has been impossible heretofore, and it is also very easy to make the on-off operation of the light not noticeable to the human being. Therefore, when the apparatus of the present invention is used as a light source for a display apparatus, a large number of light sources each comprising a red, green, blue or white chromatic light-emitting fluorescent lamp are combined together, and by selectively turning on and off these fluorescent lamps it is possible to let a viewer sense the blinking of the lights.

Another form of the circuit arrangement of the apparatus according to this invention is shown in FIG. 5, which is designed to control the brilliance modulation of an associated fluorescent lamp intermittently at a high speed by the pulse amplitude modulation method. With reference to FIG. 5, reference numeral 31 designates a fluorescent lamp having a hot negative electrode 32, a main positive electrode 33 and an auxiliary positive electrode 34; 35 and 36 transistors for the current amplification of a waveform which is an input for the fluorescent lamp 31 and which has been modulated by pulse amplitude modulation; 37 a diode adapted to pass the modulated waveform but prevent the discharge current of a capacitor from flowing to the signal side upon discharge of said capacitor; 38 a capacitor for holding the input signal (a) modulated by pulse amplitude modulation; 39 a silicon con-

trolled rectifier for forcibly discharging the charge held by the capacitor 38; 40 and 41 a capacitor and a resistor respectively for triggering the gate of the silicon-controlled rectifier 39; and 42 a resistor. The elements 35 to 42 mentioned above form a brilliance modulator of the fluorescent lamp 31. Reference numeral 44 designates a variable resistor by which a current flowing through the fluorescent lamp 31 is adjusted, 45 a high-voltage, direct-current power source for impressing a voltage across the auxiliary positive electrode 34 and the hot negative electrode 32 of the fluorescent lamp 31 through a resistor 46 of high resistance value, 47 a heating power source for the hot negative electrode 32, and 49 a main direct-current power source from which a current is supplied to the fluorescent lamp 31 through the brilliance modulator 43. Reference numeral 48 designates a video signal input means to impress a video signal on the brilliance modulator 43 at a terminal 49.

The apparatus constructed as described above operates in the following manner: Namely, an auxiliary discharge is previously caused in the fluorescent lamp 31 by impressing a high voltage on the auxiliary positive electrode 34 from the high-voltage power source 45 through the resistor 46, while impressing a heating voltage on the hot negative electrode 32 from the heating power source 47. When an output of the video signal input means 48, modulated by pulse amplitude modulation, is impressed on the input terminal 49 of the brilliance modulator 43, the signal is stored in the capacitor 38 through the diode 37. When the signal being supplied to the terminal 49 is interrupted, the capacitor 38 begins to discharge the current stored therein but since the resistance of the diode 37, the silicon-controlled rectifier 39, the transistors 35, 36 and the fluorescent lamp 31 are large, the input signal is held in the capacitor 38. A control signal is fed to the gate of the silicon-controlled rectifier 39 through the trigger circuit, consisting of the capacitor 40 and the resistor 41, with a time delay relative to the aforesaid input signal, whereupon the silicon-controlled rectifier 39 is turned on and the input signal being held in the capacitor 38 is discharged completely.

The transistors 35, 36 and the resistor 42 compose an amplifier circuit for amplifying the input signal by current amplification. If the control signal is not applied to the gate of the silicon-controlled rectifier 39, a current adjusted by the brilliance adjusting resistor 44 flows through the fluorescent lamp 31, whereby an arc discharge occurs in the fluorescent lamp between the main positive electrode 33 and the hot negative electrode 32 and thus the fluorescent lamp is turned on.

As described above, the main discharge between the main positive electrode 33 and the hot negative electrode 32 lasts unless the control signal is given to the gate of the silicon-controlled rectifier, and the fluorescent lamp 31 emits a brilliant light. The auxiliary discharge is of course maintained during this period.

Now, when the control signal is applied, the fluorescent lamp 31 is shifted from the state of glow discharge to the state of arc discharge, with substantially no current flowing therethrough, and the lamp becomes dark.

The operational waveform of the circuit described above will be explained with reference to FIG. 6. Referring to FIG. 6, reference character (a) designates the input signal, that is, the output of the video signal input means 48. When a pulse amplitude modulated waveform is fed to the brilliance modulator with pulse repeating time T , a pulse width t_r and an amplitude $\frac{1}{2}V$, a voltage of amplitude $\frac{1}{2}V$ is impressed on the capacitor 38 and held therein until a time $[T-(t_r+t_d)]$ is expired from the time of feeding of the input signal (a), and is discharged by the control pulse. The control signal (b) is fed at a time $[T-(t_r+t_d)]$ after the time of rise of the input signal (a) and is indicated by a signal having a pulse width t_d and a repeating time T . In this case, a current i flows through the fluorescent lamp 31 from the emitter of the transistor 36.

Then, the input signal (a) having a pulse width V is fed to the brilliance modulator, whereupon a voltage V' is developed across the terminals of the holding capacitor 38 and the out-

put current of the transistor 36 becomes 2i. In the manner described above, the output current of the brilliance modulator 43 flows in proportion to the pulse size of the input signal (a) and the current flows between the main positive electrode 33 and the hot negative electrode 32 of the fluorescent lamp 31 at each time the state of said fluorescent lamp is shifted from auxiliary discharge to main discharge. By using a pulse of time t as the horizontal synchronized signal of a video signal, the video signal can also be used as the input signal.

As may be understood from the foregoing, brilliance control of the fluorescent lamp can be attained by the input signal which is the so-called pulse amplitude modulation wave having a variable amplitude, and the control signal (b) impressed on the gate of the silicon-controlled rectifier. Furthermore, since the auxiliary discharge is previously generated in the fluorescent lamp, there are such advantages that the control electrode can be controlled at high speed by the input signal (a) and the control signal (b), and that the tube current can be controlled relatively by the variable resistor 44.

FIG. 7 shows still another form of the circuit arrangement of the present apparatus which is designed, not to control the value of the discharge current as above described but to control the duration of the discharge. In FIG. 7, reference numerals 51 and 52 designate input terminals and 53 designates a diode having connected to the cathode side thereof a triangular wave generating time constant circuit and the base of an emitter follower transistor 56, said time constant circuit being composed of a capacitor 54 and a resistor 55. A variable resistor 57 is connected to the emitter side of the transistor 56 to control the amplification degree of said transistor, and a sliding member of said variable resistor is connected to the base side of a transistor 59. The transistor 59 has a resistor 60 connected to the emitter side thereof, and a waveform shaping circuit and the base of an emitter follower transistor 63 connected to the collector side thereof, said waveform shaping circuit being composed of a resistor 61 and a Zener diode 62. The transistor 63 has a resistor 64 and the base of a fluorescent lamp controlling transistor 65 connected to the emitter side thereof. Reference numerals 66 and 67 designate power sources for energizing the transistors 56, 59 and 63. The junction between the power sources 66 and 67 is grounded. The transistor 65 has a resistor 68 connected to the emitter side and the main positive electrode of a fluorescent lamp 69 connected to the collector side thereof. The fluorescent lamp 69 is of the same construction as described previously. Reference numeral 70 designates a resistor through which a voltage is impressed on the auxiliary positive electrode of the fluorescent lamp from a bias power source 71, 72 a heating power source for the fluorescent lamp 69, and 73 a power source for the transistor 65, from which a current is supplied to the fluorescent lamp 69.

The operation of the apparatus constructed as described above will be explained with reference to FIG. 8. When a pulse of high basic frequency ((a) in FIG. 8), obtained by sampling a video signal, is impressed across the input terminals 51 and 52, a voltage is impressed on the time constant circuit, composed of the capacitor 54 and the resistor 55, through the diode 53 and a time constant waveform ((b) in FIG. 8) according to the input pulse (a) is obtained. In this case, the width of the input pulse (a) is narrow, whereas a width of several milliseconds is required for the transistor 63, so that the resistance value of the resistor 55 must be sufficiently large. The input signal cannot be used as such as a control signal. Therefore, the emitter follower transistor 56 is provided for impedance matching and the emitter output of the transistor 56 is amplified by the following transistor 59. The triangular wave amplified by the transistor 59 is clipped by the Zener diode 62 connected to the collector side of said transistor 59. This is for the purpose of impressing a constant stable voltage on the base of the transistor 65 and thereby obtaining the stable operation of said transistor irrespective of the level change of the input pulse (a). The resultant trapezoidal wave is fed to the transistor 63 and a voltage of a

waveform as shown in FIG.(c) is impressed on the base of the transistor 65. Consequently, a current of the waveform shown in FIG. 8(d) flows through the transistor 65 and this current makes the fluorescent lamp 69 luminous which is connected to the collector side of said transistor 65.

Namely, an input level change results in a modulation of the pulse width and consequently in a change in the period of energization of the transistor 65. Therefore, the current is amplified and the intensity of the fluorescent lamp is adjusted.

Since, as described above, the input level, i.e. the pulse width of the sampled video signal, is made sufficiently large by the circuit and the output of the circuit is used as the input of the fluorescent lamp, a desired brilliance of the fluorescent light can be obtained in a short period of time.

We claim:

1. A discharge lamp lighting apparatus comprising a discharge lamp having one hot negative electrode and two positive electrodes, a first direct-current power source connected between said hot negative electrode and either one of said positive electrodes for generating an auxiliary discharge thereacross, a second direct-current power source for generating an arc discharge across said negative electrode and the other one of said positive electrodes, and control means connected serially with said second direct-current power source and connected between said hot negative electrode and the other one of said positive electrodes together with said second direct-current power source, said control means having an input terminal for receiving an external signal and being operable to control generation of an arc discharge across said hot negative electrode and the other one of said positive electrodes by interrupting the current supply from said second direct-current power source intermittently in response to the external signal.
2. A discharge lamp lighting apparatus as defined in claim 1, in which said control means is composed of a switching element, a unidirectional thyristor having a gate electrode and connected in series with said switching element, a gate signal generator for controlling the state of energization of said switching element, and a pulse generator connected between the gate and the cathode of said unidirectional thyristor for controlling the conduction of said unidirectional thyristor, the power being supplied to the discharge lamp intermittently through said switching element and said thyristor.
3. A discharge lamp lighting apparatus as defined in claim 1, in which said control means is composed of a diode, a capacitor for accumulating and holding a signal impressed thereon through said diode, a unidirectional thyristor connected in parallel with said capacitor and having a gate electrode to receive an external trigger signal, and a transistor amplifier having emitter and collector electrodes connected to the other one of said positive electrodes and said second direct-current power source respectively and having a base electrode connected to said capacitor, the state of conduction of said transistor amplifier being controlled by a voltage developed across the terminals of said capacitor, said transistor amplifier controlling the discharge current of the discharge lamp in response to the external signal voltage throughout the period when the signal is held by said capacitor, and said unidirectional thyristor being triggered to be turned on to eliminate the signal held in said capacitor and thereby turn off the fluorescent lamp.
4. A discharge lamp lighting apparatus as defined in claim 1, in which said control means is composed of a diode, a capacitor for accumulating a signal supplied thereto through said diode, a resistor connected in parallel with said capacitor, a transistor amplifier having a base electrode connected to said capacitor for amplifying a voltage developed across the terminals of said capacitor by the discharge current of the capacitor flowing through said resistor, a voltage regulating means connected to an output terminal of said transistor am-

plifier, a switching transistor having a base electrode connected to said voltage regulating means and having collector and emitter electrodes connected to the other one of said positive electrodes of said discharge lamp and said second direct-current power source respectively, said switching transistor being operable to interrupt the current supply from said second direct-current power source intermittently.

5. A discharge lamp lighting apparatus as defined in claim 1, in which said control means including parallel-connected capacitor and capacitor-discharging-path means, and having an input terminal connected to said capacitor for receiving an external signal to thereby charge said capacitor from said external signal.

10

15

20

25

30

35

40

45

50

55

60

65

70

75