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(19) **United States**(12) **Patent Application Publication** (10) **Pub. No.: US 2005/0253536 A1****Oyama**(43) **Pub. Date: Nov. 17, 2005**(54) **FLUORESCENT LAMP DRIVER AND
LIQUID CRYSTAL DISPLAY APPARATUS**(52) **U.S. Cl. 315/291; 315/220; 315/276;
315/307; 345/76**(76) **Inventor: Yoshiki Oyama, Kanagawa (JP)**(57) **ABSTRACT**

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NEW YORK, NY 10151 (US)**(21) **Appl. No.: 11/126,773**(22) **Filed: May 11, 2005**(30) **Foreign Application Priority Data**

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In order to suppress leak current at the time of high voltage application to a fluorescent lamp so as to improve the luminous efficiency, the present invention provides a fluorescent lamp driver, which includes switching means that switches a DC power supply voltage, and a first transformer and a second transformer configured to obtain AC voltages each having reverse polarity, as AC voltages excited from primary winding to secondary winding of the respective transformers, on the basis of output voltages of the switching means, in which the first transformer and the second transformer are positioned in the vicinity of both ends of the fluorescent lamp, and the AC voltage obtained in the secondary winding of the first transformer is applied to one terminal of the fluorescent lamp and the AC voltage obtained in the secondary winding of the second transformer is applied to the other terminal of the fluorescent lamp.

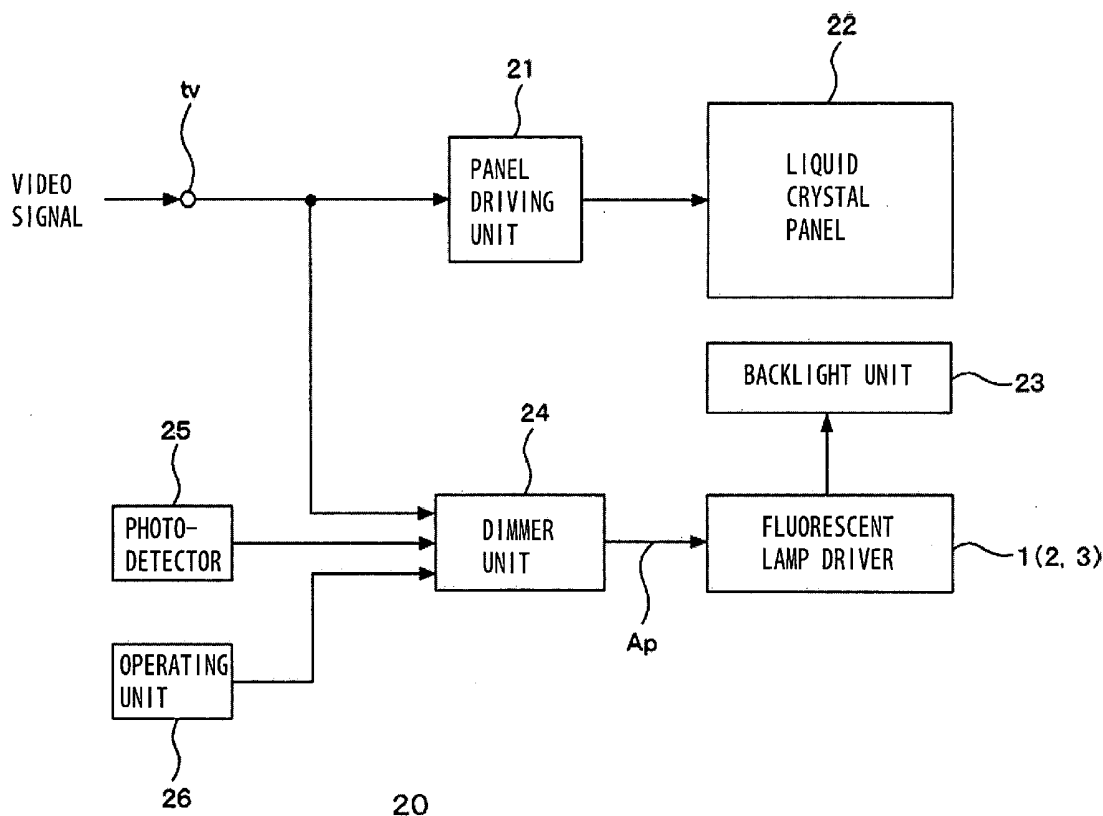


FIG. 1

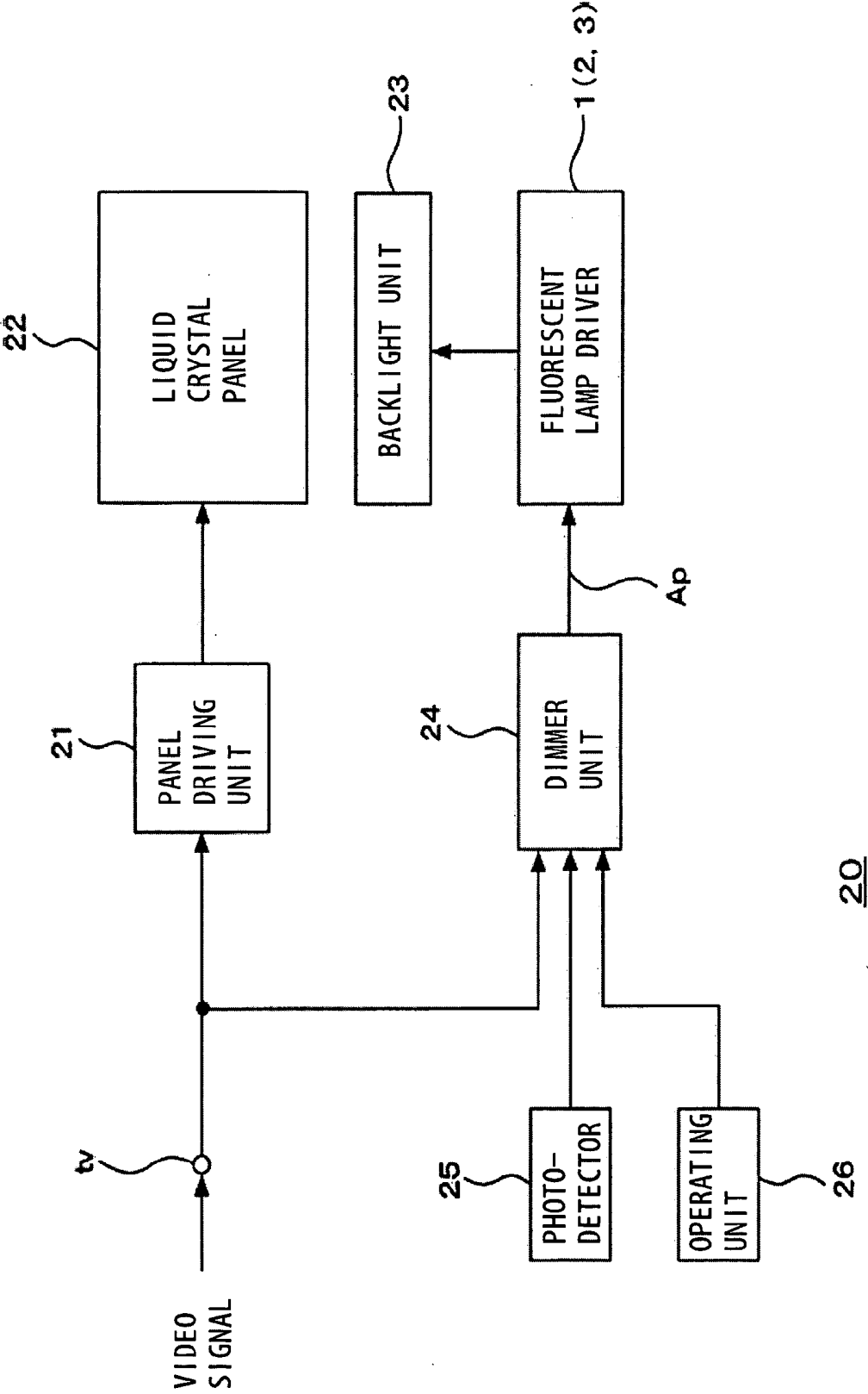


FIG. 2

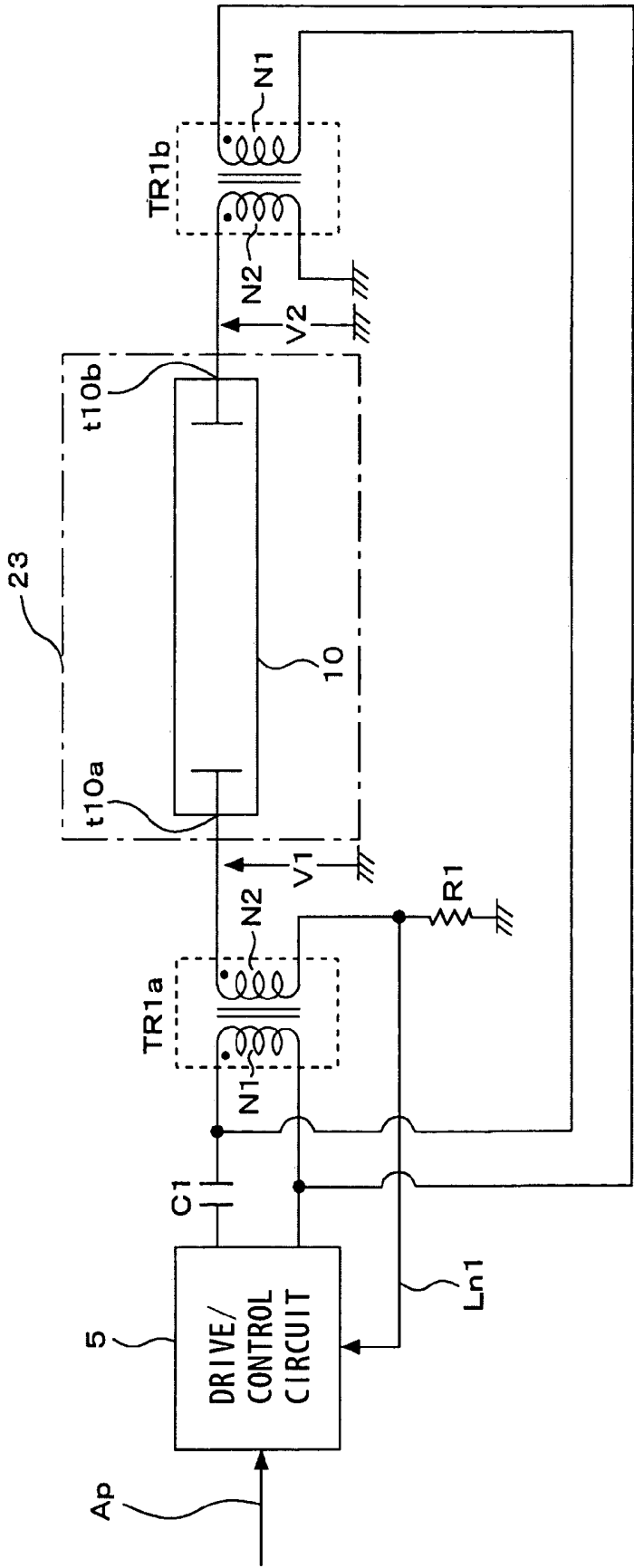


FIG. 3A

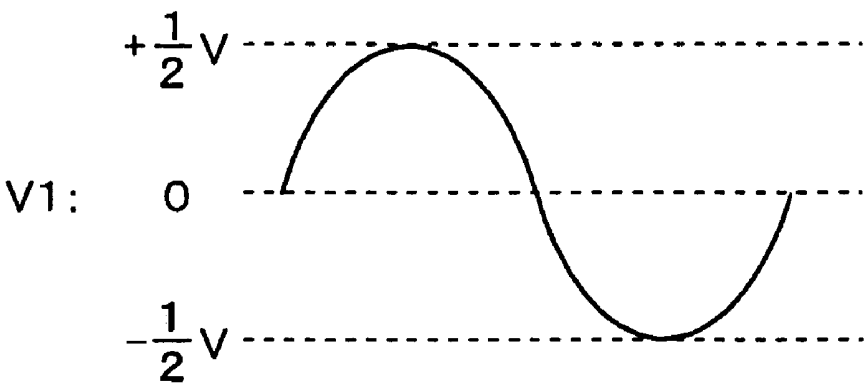
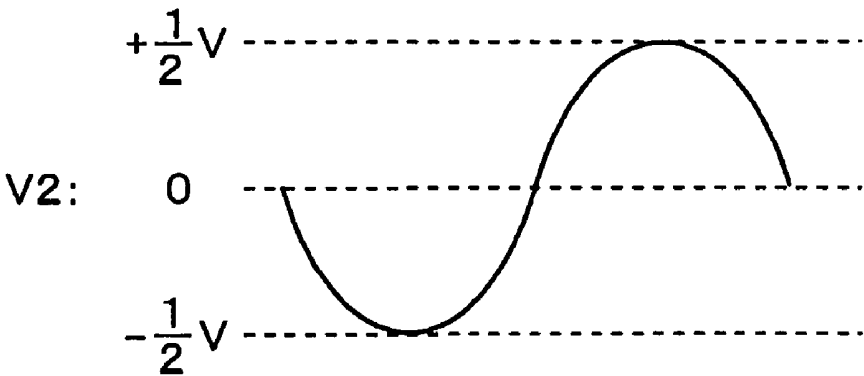


FIG. 3B



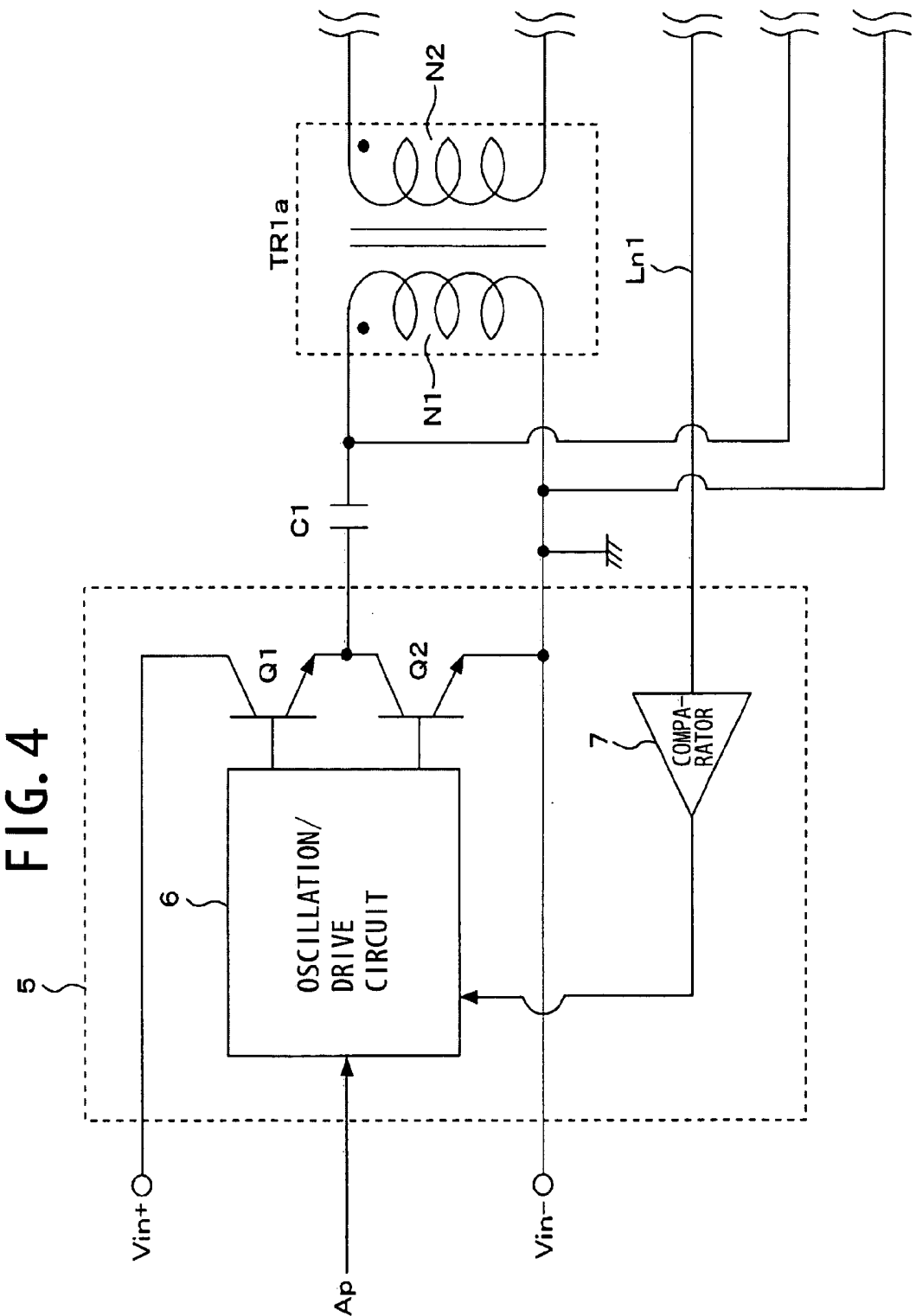


FIG. 5

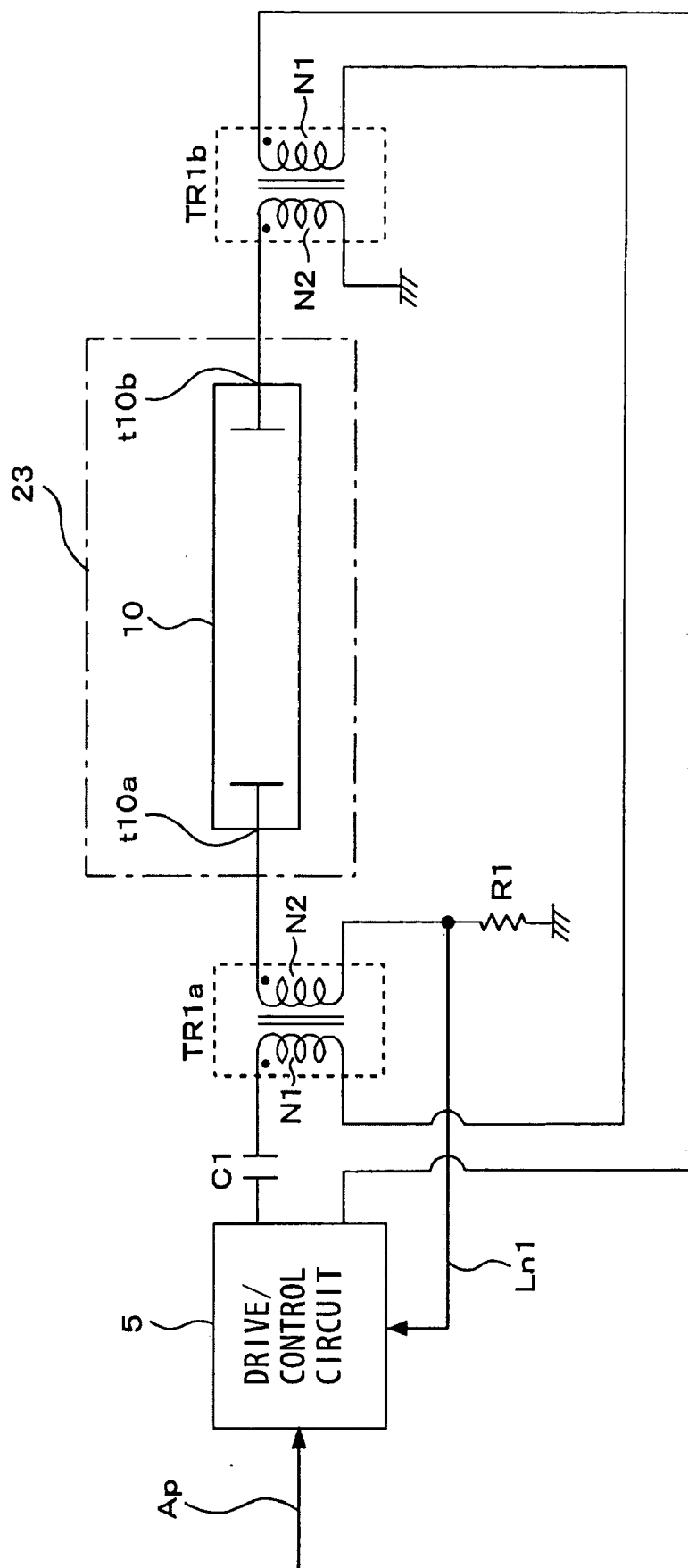


FIG. 6

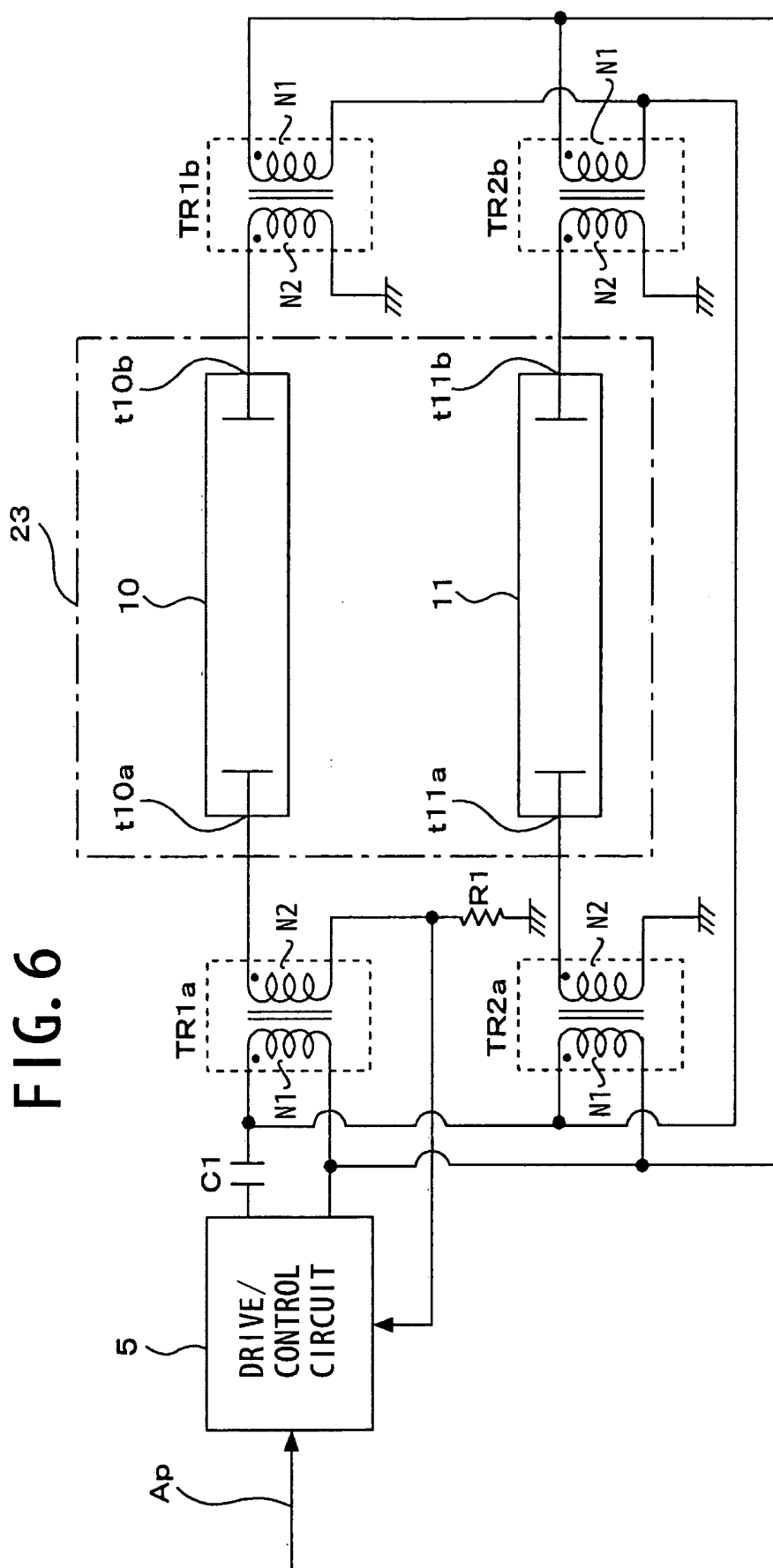
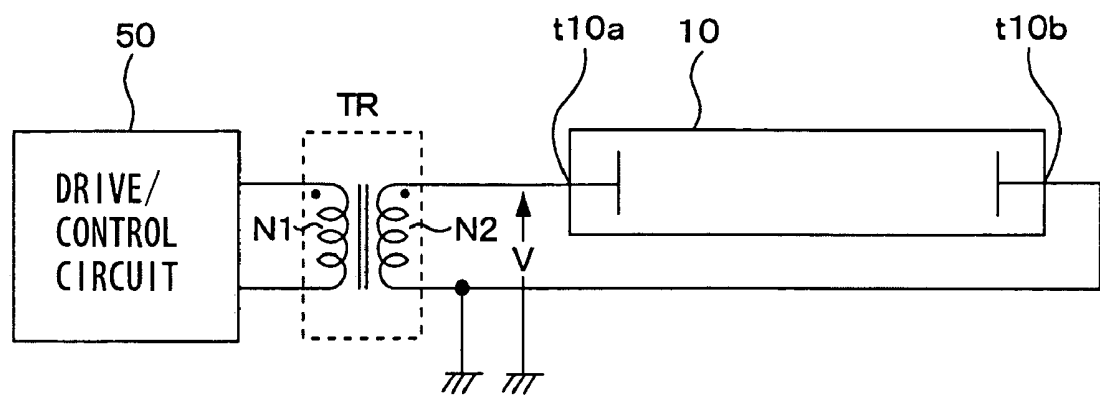
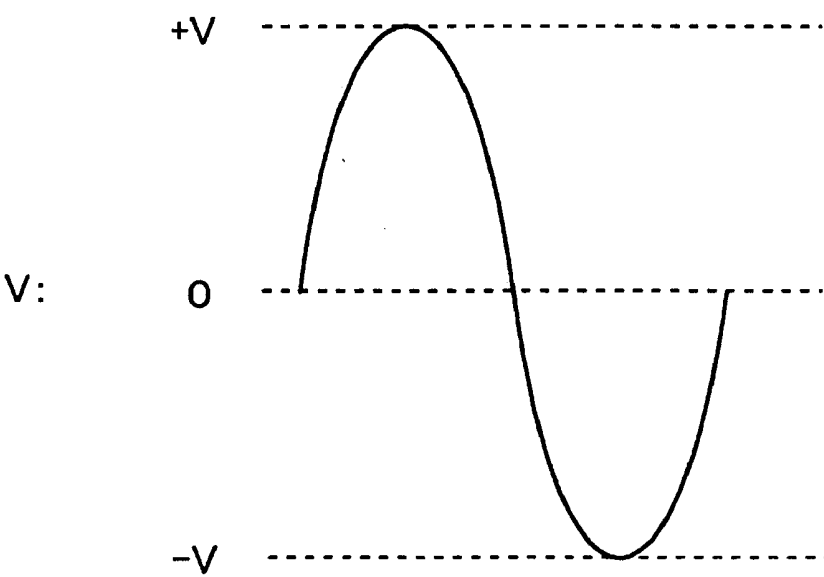


FIG. 7



RELATED ART

FIG. 8



RELATED ART

FLUORESCENT LAMP DRIVER AND LIQUID CRYSTAL DISPLAY APPARATUS

CROSS REFERENCES TO RELATED APPLICATIONS

[0001] The present document contains subject matter related to Japanese Patent Applications JP 2004-143510 and JP 2005-035445 filed in the Japanese Patent Office on May 13, 2004 and Feb. 14, 2005, the entire contents of which being incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a fluorescent lamp driver for driving a fluorescent lamp to emit light and to a liquid crystal display apparatus.

[0004] 2. Description of Related Art

[0005] For example, in a display apparatus that is not of a self-luminous type such as a liquid crystal display, a backlight using a cold cathode fluorescent lamp (CCFL) as a light source is provided. FIG. 7 schematically illustrates a constitution of a fluorescent lamp driver of a related art for driving the cold cathode fluorescent lamp as a backlight provided in such a liquid crystal display apparatus. In FIG. 7, a drive/control circuit 50 is provided with a switching element or the like therein so as to receive power supply from a DC power source not shown in the figure to generate an AC voltage. This AC voltage generated by this drive/control circuit 50 is supplied to primary winding N1 of a transformer TR.

[0006] The transformer TR is a step-up or step-down transformer and excites an AC voltage received from the drive/control circuit 50 to output to secondary winding N2. One end of the secondary winding N2 of the transformer TR is connected to one terminal t10a of a cold cathode fluorescent lamp 10, while the other end of the second winding N2 is connected to the other terminal t10b of the cold cathode fluorescent lamp 10, and at the same time, connecting points of them are grounded.

[0007] In the example of the related art, there has been employed a constitution in which the terminal t10b of the cold cathode fluorescent lamp 10 is set to an earth potential or a potential close thereto while an AC voltage is applied to the terminal t10a. Namely, in the fluorescent lamp driver in this case, as shown in FIG. 8, for example, by applying a voltage V having $\pm V$ level taking 0 level as a reference to the terminal t10a of the cold cathode fluorescent lamp 10, the cold cathode fluorescent lamp 10 is driven to emit light.

[0008] As the related art, the following patent document can be cited.

[0009] [Patent Document 1] Japanese Patent Application Publication (KOKAI) No. 11-8087

SUMMARY OF THE INVENTION

[0010] In recent years, as a screen of a display apparatus has been increasingly made larger, a cold cathode fluorescent lamp used as a backlight has been increasingly made longer. Thus, as the cold cathode fluorescent lamp is increasingly made longer, a higher voltage needs to be applied for

driving the cold cathode fluorescent lamp. A high driving voltage increases a leak current component flowing through a capacitive coupling component between the cold cathode fluorescent lamp and its surroundings. Since this leak current does not contribute to the light emission of the cold cathode fluorescent lamp, the increase in the leak current may lead to a decrease in luminous efficiency.

[0011] Furthermore, there occurs a phenomenon that the leak current component becomes higher at a position closer to the opposite side (that is, grounding wire side) of the voltage applied side of the cold cathode fluorescent lamp 10, while the luminance becomes lower. In other words, in a longitudinal direction of the cold cathode fluorescent lamp 10, there occurs luminance unevenness that the terminal t10a side is bright and the terminal t10b side is dark.

[0012] In light of the foregoing, according to the constitution as shown in FIG. 7, as the cold cathode fluorescent lamp is increasingly made longer due to the large screen of the display, the leak current is disadvantageously increased, thereby deteriorating the luminous efficiency and facilitating the occurrence of the luminance unevenness.

[0013] In the above-mentioned Patent Document 1, a constitution is described in which two sets of drive circuits and transformers for driving a cold cathode fluorescent lamp are prepared and arranged at both ends of the cold cathode fluorescent lamp to apply voltages each having reverse polarity from the respective ends. Thus, according to the constitution in which the voltages each having reverse polarity are applied from both ends, double the voltage level applied to each of the ends can be consequently applied to the cold cathode fluorescent lamp at this time. Namely, in this case, the voltage level to be applied from each of the sets of drive circuits/transformers can be reduced to be one-half of the case where the cold cathode fluorescent lamp is driven by only one set of drive circuit/transformer. Thus, a decrease in voltage level to be applied to the terminal of the fluorescent lamp reduces the leak current, thereby achieving high efficiency. Furthermore, in this case, since the voltages are applied from both sides, not from one side, such phenomenon of luminance unevenness as that the luminance is decreased on one side of the cold cathode fluorescent lamp and so on can be suppressed. However, according to such a constitution of Patent Document 1, it is necessary for driving one cold cathode fluorescent lamp to provide at least a plurality of sets of drive circuits, control circuits and transformers. For example, since in a display of 40-inch class, twenty cold cathode fluorescent lamps are used, if a plurality of sets of drive circuits, control circuits and transformers are provided for one cold cathode fluorescent lamp, a circuit area and manufacturing costs are considerably increased.

[0014] In the present invention, in light of the above-mentioned problems, a fluorescent lamp driver is configured to have switching means for switching a DC power supply voltage, and a first transformer and a second transformer designed to obtain AC voltages each having reverse polarity as AC voltages excited from primary winding to secondary winding of the respective transformers, on the basis of output voltages of the above-mentioned switching means. In addition, the first transformer and the second transformer are arranged to be located on both ends of the fluorescent lamp in a longitudinal direction, and then the AC voltage obtained in the secondary winding of the first transformer is applied

to one terminal of the fluorescent lamp and the AC voltage obtained in the secondary winding of the second transformer is applied to the other terminal of the fluorescent lamp.

[0015] Furthermore, in the present invention, a liquid crystal display apparatus is configured to have at least a liquid crystal panel and a backlight unit using a fluorescent lamp to display an image. The liquid crystal display apparatus first has switching means for switching a DC power supply voltage as a fluorescent lamp driving unit for driving the fluorescent lamp to emit light. The liquid crystal display apparatus further comprises, as the fluorescent lamp driving unit, a first transformer and a second transformer designed to obtain AC voltages each having reverse polarity as AC voltages excited from primary winding to secondary winding of the respective transformers, on the basis of output voltages of the switching means. In addition, the fluorescent lamp driving unit is configured such that the first transformer and the second transformer are arranged to be located on both ends of the fluorescent lamp in a longitudinal direction, and then the AC voltage obtained in the secondary winding of the first transformer is applied to one terminal of the fluorescent lamp and the AC voltage obtained in the secondary winding of the second transformer is applied to the other terminal of the fluorescent lamp.

[0016] According to the above-mentioned constitution, in the first transformer and the second transformer, the AC voltages each having reverse polarity are obtained at the secondary winding on the basis of the output voltages from one switching means (drive circuit). Then, the AC voltages each having reverse polarity obtained in the secondary winding of these first transformer and second transformer are applied from both sides of the fluorescent lamp. Thus, by employing the constitution in which the AC voltages each having reverse polarity are applied from both sides of the fluorescent lamp, respectively, the voltage level to be applied to each of the terminals of the fluorescent lamp can be reduced to one-half of the voltage level of the constitution of the related art in which the output by one transformer is applied to only one terminal of the fluorescent lamp. Namely, since the voltage level to be applied to each of the terminals can be reduced in this manner, the leak current can also be reduced.

[0017] Furthermore, by employing the constitution in which the voltages are applied from both sides of the fluorescent lamp, luminance unevenness that only the voltage applied side becomes brighter, for example, as in a case where a high voltage is applied to only one side or the like can be reduced. In addition, the present invention employs the constitution of obtaining the voltages each having reverse polarity in the first transformer and the second transformer, which can make it unnecessary to provide both the transformer and the drive circuit on each side of the fluorescent lamp.

[0018] Thus, according to the present invention, the voltage level to be applied to the fluorescent lamp can be reduced to one-half of the voltage level required in the related art, thereby reducing the leak current. In addition, such a reduction in leak current can improve the luminous efficiency. Furthermore, by employing the constitution in which the voltages are applied from both sides of the fluorescent lamp using the two transformers, the luminance unevenness can be suppressed.

[0019] Furthermore, in the present invention, by employing the constitution of obtaining the voltages each having reverse polarity in the first transformer and the second transformer on the basis of the output voltages of one drive circuit, both the transformer and the drive circuit do not need to be provided on each side of the fluorescent lamp, thereby reducing a circuit area and circuit manufacturing costs as compared with the case where both the transformer and the drive circuit are provided on each side of the fluorescent lamp.

[0020] Furthermore, in the present invention, by arranging the first transformer and the second transformer to be located on both ends of the fluorescent lamp, a length of wiring for connecting the secondary winding of each of the transformers and each of the terminals of the fluorescent lamp can be made as short as possible. Such a short wiring length from the secondary winding to the terminal of the fluorescent lamp can further suppress the leak current, further improving the luminous efficiency.

[0021] Since the two transformers are provided to reduce the voltage level to be applied to each of the terminal of the fluorescent lamp, a core size of the first transformer and the second transformer in this case can be smaller than that in the case of the related art where a high voltage is applied with only one transformer.

[0022] Thereby, a core of the transformer can be thinner than that of the one in the related art, so that the fluorescent lamp driver, and further the liquid crystal display apparatus can be thinner than the related art ones.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] FIG. 1 is a block diagram showing a structural example of a liquid crystal display apparatus as one embodiment of the present invention;

[0024] FIG. 2 is a view showing a structural example of a fluorescent lamp driver in a first embodiment of the present invention;

[0025] FIG. 3A and FIG. 3B are views exemplifying voltage waveforms applied to a fluorescent lamp in the fluorescent lamp driver of the embodiment;

[0026] FIG. 4 is a view showing an internal structural example of a drive/control circuit provided in the fluorescent lamp driver of the embodiment;

[0027] FIG. 5 is a view showing a structural example of a fluorescent lamp driver in a second embodiment of the present invention;

[0028] FIG. 6 is a view showing a structural example of a fluorescent lamp driver in a third embodiment of the present invention;

[0029] FIG. 7 is a view showing a structural example of a fluorescent lamp driver of a related art; and

[0030] FIG. 8 is a view exemplifying a voltage waveform applied to a fluorescent lamp in the fluorescent lamp driver of the related art.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0031] Hereinafter, preferred embodiments for carrying out the invention (hereinafter, referred to as embodiments) are described.

[0032] Firstly, with reference to a block diagram of FIG. 1, a liquid crystal display apparatus 20, which comprises a fluorescent lamp driver, is described. In FIG. 1, a video signal is first inputted from a video terminal tv as illustrated. This video signal is supplied to a panel driving unit 21 and a dimmer unit 24.

[0033] The panel driving unit 21 applies necessary video signal processing to the inputted video signal to generate a driving signal for driving a liquid crystal panel 22 so as to display an image in accordance with the inputted video signal. In this manner, the liquid crystal panel 22 displays an image in accordance with the above-mentioned video signal by performing the operation in response to the driving signal generated in the panel driving unit 21.

[0034] The dimmer unit 24 generates a dimming signal Ap for adjusting the light amount of a backlight unit 23. In this case, the light amount adjustment of the backlight unit 23 is first performed on the basis of the video signal supplied as described above. Namely, the dimmer unit 24 detects, from the inputted video signal, luminance information of the image to be displayed, and sets the dimming signal Ap so as to give the light amount in accordance with this luminance information.

[0035] Furthermore, secondly, the above-mentioned setting is also made on the basis of light amount information detected in a photodetector 25 as illustrated. This photodetector 25 is constituted so as to detect the light amount, for example, in a part exposed outside a case of the display apparatus 20, thereby detecting a light amount in circumstances where the display apparatus 20 is placed. The dimmer unit 24 is designed to set the dimming signal Ap in accordance with the light amount information from the photodetector 25.

[0036] Furthermore, thirdly, the adjustment is made to follow with manual operation of a user. This manual adjustment can be performed, for example, by selecting an item such as "brightness adjustment" from a menu screen for various settings. Such manual adjustment can be made via an operating unit 26 as illustrated. The dimmer unit 24 is also designed to set the dimming signal Ap in accordance with operational information from this operating unit 26.

[0037] The dimming signal Ap set in the dimmer unit 24 in accordance with these video signal, light amount information from the photodetector 25 and operation input is supplied to a fluorescent lamp driver 1, 2 or 3. As the operating unit 26, a user interface using a remote controller can also be employed.

[0038] Each of fluorescent lamp driver circuits 1, 2 and 3 shows the fluorescent lamp driver according to each of the embodiments of the present invention. The fluorescent lamp driver 1 (2, 3) of the respective embodiments will be described in detail later.

[0039] The backlight unit 23 comprises a cold cathode fluorescent lamp as a light source in this case and is driven to emit light in accordance with the application of a driving voltage generated by the fluorescent lamp driver 1 (2, 3), as described later. At this time, the adjustment of the light amount of the backlight unit 23 is made by adjusting the generation level of the above-mentioned driving voltage in the fluorescent lamp driver 1 (2, 3) in accordance with the dimming signal Ap generated by the dimmer unit 24 as described above.

[0040] Subsequently, with reference to FIGS. 2 to 4, the fluorescent lamp driver 1 as a first embodiment in the present invention is described.

[0041] FIG. 2 is a diagram showing a structural example of the fluorescent lamp driver 1 as the first embodiment. This diagram also shows the backlight unit 23 as shown in FIG. 1. Here, for convenience in description, an example in which the backlight unit 23 comprises only one cold cathode fluorescent lamp 10 is shown.

[0042] In FIG. 2, for the fluorescent lamp driver 1 of the first embodiment, at least one drive/control circuit 5 (switching means and switching driving means) and two transformers, a transformer TR1a (first transformer) and a transformer TR1b (second transformer), are provided to drive the illustrated cold cathode fluorescent lamp 10.

[0043] Firstly, the dimming signal Ap from the dimmer unit 24 as previously shown in FIG. 1 is supplied to the drive/control circuit 5. A DC power supply voltage not shown in the figure is inputted to this drive/control circuit 5 to generate AC voltages. These AC voltages are supplied to respective primary winding N1 of the transformer TR1a and the transformer TR1b as illustrated. The internal constitution of the drive/control circuit 5 will be described later.

[0044] The AC voltage obtained in the primary winding N1 of the transformer TR1a is excited in a secondary winding N2 wound on the secondary side of this transformer TR1a. In this case, the winding directions of the primary winding N1 and the secondary winding N2 in the transformer TR1a are the same as illustrated, thereby obtaining the AC voltages having the same polarity in these primary winding N1 and the secondary winding N2.

[0045] The winding direction herein indicates a direction from a winding start to a winding end.

[0046] A winding start portion of the secondary winding N2 of the transformer TR1a is connected to the one terminal t10a of the cold cathode fluorescent lamp 10. A winding end portion of the secondary winding N2 is connected to a grounding wire via a current detection resistor R1 as illustrated. Accordingly, the AC voltage excited from the primary winding N1 to the secondary winding N2 in the transformer TR1a is applied to the terminal t10a of the cold cathode fluorescent lamp 10.

[0047] From a connecting point between the winding end portion of the secondary winding N2 and the current detection resistor R1, a detection line Ln1 is inputted to the drive/control circuit 5 as illustrated, which will be described later.

[0048] Furthermore, in the fluorescent lamp driver 1 of the embodiment, the transformer TR1b is provided so as to correspond to the above-described transformer TR1a. In this case, the transformer TR1a and the transformer TR1b are constituted to have equivalent characteristics, respectively. Namely, for example, winding wires and cores to be used, the respective winding numbers of the primary winding N1 and the secondary winding N2, and a gap length formed in the cores are made equivalent or similar, thereby making the respective characteristics equivalent.

[0049] Furthermore, the transformer TR1a and the transformer TR1b are arranged to be located on both sides of the cold cathode fluorescent lamp 10 in a longitudinal direction

as illustrated. Namely, the transformer TR1a is arranged on one terminal side (side of the terminal t10a) of the cold cathode fluorescent lamp 10 and the transformer TR1b is arranged on the other terminal side (side of the terminal t10b) of the cold cathode fluorescent lamp 10.

[0050] As illustrated, a winding end portion of the primary winding N1 on the transformer TR1b side is connected to a winding start portion of the primary winding N1 of the transformer TR1a. Also, a winding start portion of the primary winding N1 of the transformer TR1b is connected to the winding end portion of the primary winding N1 of the transformer TR1a. According to such a connection form, the transformer TR1a and the transformer TR1b in this case are connected in parallel.

[0051] Furthermore, according to the above-mentioned connection form, while the winding directions of the respective primary winding N1 of the transformers TR1a and TR1b are the same, the connecting directions are reverse to each other as seen from the drive/control circuit 5 as a voltage supply source, so that the AC voltages obtained in the respective primary winding N1 have reverse polarity to each other.

[0052] In the transformer TR1b, the winding directions of the primary winding N1 and the secondary winding N2 are the same as in the case of the transformer TR1a. Namely, an AC voltage having the same polarity as an AC voltage obtained in the primary winding N1 of the transformer TR1b is applied to the terminal t10b of the cold cathode fluorescent lamp 10. In addition, a winding end portion of this secondary winding N2 is grounded and a winding start portion thereof is connected to the other terminal t10b of the cold cathode fluorescent lamp 10. According to such a constitution, with respect to the terminal t10b of the cold cathode fluorescent lamp 10, an AC voltage which is excited from the primary winding N1 to the secondary winding N2 of the transformer TR1b and has polarity reverse to the AC voltage obtained in the primary winding N1 of the transformer TR1a is applied. Namely, the AC voltages each having reverse polarity are applied to the terminal t10a and the terminal t10b of the cold cathode fluorescent lamp 10 in this case.

[0053] In this manner, by applying the AC voltages each having reverse polarity to the terminal t10a and the terminal t10b of the cold cathode fluorescent lamp 10, a voltage V1 and a voltage V2 as shown in the next FIG. 3A and FIG. 3B are applied to the terminal t10a and the terminal t10b in this case, respectively. Specifically, in the related art constitution as shown in the FIG. 7, in a case where the voltage level to be applied to the terminal t10a is set to "V", the voltage V1 and the voltage V2 each of which is at the level of " $\frac{1}{2}V$ ", that is, one-half of the "V", as shown in FIGS. 3A and 3B, respectively are applied.

[0054] In this case, since the polarity of the AC voltages applied to the terminal t10a and the terminal t10b is mutually reversed as described above, for example, in a case where the voltage V1 of " $+\frac{1}{2}V$ " is applied to the terminal t10a, the voltage V1 of " $-\frac{1}{2}V$ " is applied to the terminal t10b. Namely, by applying the voltages each having the reverse polarity at the level of " $\frac{1}{2}V$ ", the voltage at "V" level can be consequently applied to the cold cathode fluorescent lamp 10. Accordingly, in this case, by applying, on both sides of the cold cathode fluorescent lamp 10, the AC voltages at one-half of the level of the related art constitution

in the above-described FIG. 7, the driving voltage similar to the related art constitution can be consequently applied to the cold cathode fluorescent lamp 10.

[0055] FIG. 4 shows an example of an internal structure of the drive/control circuit 5. In this diagram, the transformer TR1a, a resonant capacitor C1 and the detection line Ln1, which are shown in FIG. 2, are also shown.

[0056] Firstly, this drive/control circuit 5 comprises an oscillation/drive circuit 6, a switching element Q1 and a switching element Q2 which are NPN type transistors in this case, and a comparator 7, as illustrated.

[0057] As illustrated, a collector of the switching element Q1 is connected to the positive pole side of a DC power supply voltage Vin supplied to the drive/control circuit 5 and an emitter thereof is connected to a collector of the switching element Q2. Furthermore, an emitter of the switching element Q2 is connected to the negative pole side of the DC power supply voltage Vin.

[0058] To a connecting point (switching output point) between the emitter of the switching element Q1 and the collector of the switching element Q2, the winding start portion of the primary winding N1 of the transformer TR1a is connected via a serial connection of the resonant capacitor C1 as illustrated. Namely, as described in FIG. 2, since this winding start portion of the primary winding N1 is connected to the winding end portion of the primary winding N1 of the transformer TR1b, the above-mentioned switching output point is connected to a connecting point between the winding start portion of the primary winding N1 of the transformer TR1a and the winding end portion of the primary winding N1 of the transformer TR1b via the serial connection of the resonant capacitor C1.

[0059] Furthermore, the winding end portion of the primary winding N1 of the transformer TR1a is connected to the emitter of the switching element Q2. Namely, the emitter of the switching element Q2 is connected to a connecting point between the winding end portion of the primary winding N1 of the transformer TR1a and the winding start portion of the primary winding N1 of the transformer TR1b. Furthermore, a connecting point between the emitter of the switching element Q2 and the connecting point between the winding end portion of the primary winding N1 of the transformer TR1a and the winding start end portion of the primary winding N1 of the transformer TR1b is grounded as illustrated.

[0060] The oscillation/drive circuit 6 has an oscillator therein, and drives the above-mentioned switching element Q1 and switching element Q2 so as to turn on/off alternately in accordance with an oscillation signal of the oscillator. By turning on/off the switching element Q1 and the switching element Q2 alternately in this manner, alternating currents are caused to flow in the primary winding N1 of the transformer TR1a and the primary winding N1 of the transformer TR1b, which are connected to the switching output point between the switching element Q1 and the switching element Q2. By obtaining the alternating currents in the respective primary winding N1, the AC voltages are generated in the respective primary winding N1, and thereby obtaining the AC voltages also in the secondary winding N2 of the transformer TR1a and the transformer TR1b as described above.

[0061] Here, the oscillation/drive circuit 6 in this case controls switching frequencies of the switching element Q1 and the switching element Q2 in accordance with a control signal from the comparator 7, based on the input from the illustrated detection line Ln1.

[0062] In this case, as shown in FIG. 2, the current detection resistor R1 is inserted between the winding end portion of the secondary winding N2 of the transformer TR1a and the grounding wire, and a detected voltage at the level in accordance with a current flowing in the secondary winding N2 of the transformer TR1a is obtained in the detection line Ln1. The comparator 7 outputs the control signal at the level in accordance with this detected voltage supplied via the detection line Ln1 to the oscillation/drive circuit 6. The oscillation/drive circuit 6 controls the switching frequencies of the switching element Q1 and the switching element Q2 in accordance with such a control signal level from the comparator 7. This allows the current level flowing in the secondary winding N2 to be controlled so as to be constant at a set level. Namely, the light emission amount of the cold cathode fluorescent lamp 10 is controlled to be constant.

[0063] Furthermore, in this case, the dimming signal Ap from the dimmer unit 24, which is supplied to the drive/control circuit 5 as shown in FIG. 2, is inputted to the oscillation/drive circuit 6. The oscillation/drive circuit 6 also performs the switching frequency control over the switching elements Q1, Q2 in accordance with this dimming signal Ap. Namely, the current level flowing in the secondary winding N2 is also controlled in accordance with this dimming signal Ap, which allows the light amount in the backlight unit 23 to be controlled in accordance with this dimming signal Ap.

[0064] In this case, the oscillation/drive circuit 6 performs stabilizing control as described above on the basis of only the detected voltage by the current detection resistor R1 provided on the transformer TR1a side. However, as described above, since the transformer TR1a and the transformer TR1b are constituted so as to have the equivalent characteristics in this case, the stabilizing control over the secondary winding current of the transformer TR1a also works on the secondary winding current of the transformer TR1b similarly. In other words, by stabilizing the secondary winding current on the transformer TR1a side, the secondary winding current on the transformer TR1b side can be consequently stabilized similarly.

[0065] Here, as shown in FIG. 4, in the fluorescent lamp driver 1 of the first embodiment, the resonant capacitor C1 is connected in series with the primary winding N1 for the following reasons.

[0066] As can be understood from the above description with reference to FIG. 2, in the present embodiment, for the drive/control circuit 5, the transformer TR1a and the transformer TR1b arranged to be located on both sides of the cold cathode fluorescent lamp 10 are provided. Thereby, in supplying the AC voltages generated by the drive/control circuit 5, while the wiring to the primary winding N1 of the transformer TR1a, which is arranged on the drive/control circuit 5 side, can be relatively short, the wiring to the primary winding N1 of the other transformer TR1b needs to be laid longer than or equal to a length of the cold cathode fluorescent lamp 10 at least.

[0067] At this time, since the current flowing from the drive/control circuit 5 to each of the primary winding N1 has

a relatively high frequency, if the wiring from the drive/control circuit 5 to the primary winding N1 is made long, there arise concerns about noise radiation in this line. By inserting the resonant capacitor C1 to be in series with the primary winding N1 of each of the transformers TR, a resonant circuit is formed by a capacitance of this resonant capacitor C1 and a leakage inductance of the primary winding N1, which can make the current flowing on the primary side of each of the transformers TR into a sinusoidal waveform. Namely, this can reduce higher harmonics generated in the high-frequency current flowing in the line connecting from the drive/control circuit 5 side to the primary winding N1 side of the transformer TR1b, and thus the noise radiation can be suppressed.

[0068] As described heretofore, according to the fluorescent lamp driver 1 of the present embodiment, by employing the constitution in which the AC voltages each having the reverse polarity are applied on both sides of the cold cathode fluorescent lamp 10, the voltage level to be applied to each of the terminals of the cold cathode fluorescent lamp 10 can be reduced to one-half of the level in the case of the related art constitution in which output by one transformer is applied to only one terminal of the cold cathode fluorescent lamp 10. In this manner, since the voltage level to be applied to the terminal of the cold cathode fluorescent lamp 10 can be decreased, the leak current can be reduced. The reduction in leak current in this manner can improve the luminous efficiency.

[0069] Furthermore, in this manner, by employing the constitution in which the AC voltages are applied from both sides of the cold cathode fluorescent lamp 10, there can be reduced luminance unevenness that only the voltage applied side becomes bright when a high voltage is applied to only one terminal in the related art and so on.

[0070] Furthermore, according to the fluorescent lamp driver 1 of the present embodiment, in order to realize the constitution in which the AC voltages are applied from both sides of the cold cathode fluorescent lamp 10 as described above, as the transformers receiving the supply of the AC voltages from the drive/control circuit 5 generating the alternating voltage for driving, the two transformers connected so as to obtain the AC voltages each having reverse polarity in the respective secondary winding are provided, which can make it unnecessary that drive circuits for generating the AC voltages each having reverse polarity are provided on both sides of the cold cathode fluorescent lamp 10. Namely, in this point, when realizing the constitution in which the AC voltages are applied from both sides of the cold cathode fluorescent lamp 10, increases in circuit area and circuit manufacturing costs can be suppressed.

[0071] Furthermore, by employing the constitution in which the transformer TR1a and the transformer TR1b are provided to apply the AC voltages from both sides of the cold cathode fluorescent lamp 10 as described above, a core size of the transformer TR1a and the transformer TR1b in this case can be made smaller as compared with the related art constitution in which only one transformer is provided to apply a high voltage on only one side of the cold cathode fluorescent lamp 10. This allows cores of the transformers TR to be thinner than the one in the related art, thereby achieving the thinner backlight unit 23 and further the thinner liquid crystal display apparatus 20 than the one in the related art.

[0072] Here, in the present embodiment, the reason why the transformer TR1a and the transformer TR1b are arranged to be located on both sides of the cold cathode fluorescent lamp 10 as described above is as follows.

[0073] For example, if the transformer TR1b is arranged on the same side as the transformer TR1a, the wiring from the secondary winding N2 of the transformer TR1b to the other terminal of the cold cathode fluorescent lamp 10 needs to be laid longer than or equal to at least the length of the cold cathode fluorescent lamp 10. Such longer wiring from the secondary winding N2 to the terminal of the cold cathode fluorescent lamp 10 may also increase the leak current level. Namely, when the wiring from the secondary winding N2 to the terminal of the cold cathode fluorescent lamp 10 is made long, the effect of suppressing the leak current by the reduction in the applied voltage level will also be reduced. In particular, in the constitution in which a relatively high-voltage, high-frequency driving voltage is applied as in the cold cathode fluorescent lamp, such an increase in the leak current level due to the increased wiring length from the secondary winding N2 to the terminal of the cold cathode fluorescent lamp becomes serious.

[0074] In the present embodiment, by arranging the transformer TR1a and the transformer TR1b on the respective terminal sides of the cold cathode fluorescent lamp 10, the wiring lengths from the secondary winding N2 to the terminals are minimized on both sides of the cold cathode fluorescent lamp 10. As a result of the arrangement, the leak current level can be minimized. Accordingly, in the present embodiment, the luminous efficiency is improved by arranging the transformer TR1a and the transformer TR1b to be located on both ends of the cold cathode fluorescent lamp 10.

[0075] Furthermore, according to the liquid crystal display apparatus 20 of the embodiment comprising the fluorescent lamp driver 1 as the present embodiment as described above, in the backlight unit 23, the luminous efficiency can be improved and the luminance unevenness can be reduced, and further a thinner liquid crystal display apparatus can be realized.

[0076] Subsequently, a constitutional example of a fluorescent lamp driver 2 according to a second embodiment of the present invention is illustrated in FIG. 5. In FIG. 5, the same reference numerals are given to the similar parts to those described in FIG. 2. Also, a drive/control circuit 5 as shown in this figure has a similar constitution to the one described in FIG. 4. In this embodiment, a case where only one cold cathode fluorescent lamp 10 is used in a backlight unit 23 is also exemplified.

[0077] Referring to FIG. 5, in the fluorescent lamp driver 2 of the second embodiment, a transformer TR1a and a transformer TR1b, which are connected in parallel in the case of the first embodiment, are connected in series. In this case, a winding start portion of primary winding N1 of the transformer TR1a is, similar to the case in FIG. 4, connected to a connecting point (switching output point) between an emitter of a switching element Q1 and a collector of a switching Q2 inside the drive/control circuit 5 via the series connection of a resonant capacitor C1.

[0078] Different from the case in FIG. 4, a winding end portion of the primary winding N1 of the transformer TR1a

is not connected directly to an emitter of the switching element Q2 inside the drive/control circuit 5. Namely, a winding end portion of primary winding N1 of the transformer TR1b is connected to the winding end portion of the primary winding N1 of the transformer TR1a, and a winding start portion of the primary winding N1 of the transformer TR1b is connected to the emitter of the switching element Q2 inside the drive/control circuit 5.

[0079] According to such a connection form, the transformer TR1a and the transformer TR1b in this case are in a serial connection by connecting the respective primary winding N1 in series between the switching output point and the emitter of the switching element Q2 inside the drive/control circuit 5. As described above, the respective primary winding N1 is inserted in series between the switching output point and the emitter of the switching element Q2 as a serial-connected circuit in which the winding end portions of the respective primary winding N1 are connected to each other. Also, in this case, this allows the respective primary winding N1 to be connected in a reverse direction to each other with respect to the drive/control circuit 5 serving as a voltage supply source, so that AC voltages each having reverse polarity can be obtained.

[0080] In addition, in this case, since the winding direction of the primary winding N1 and the secondary winding N2 in the transformer TR1a and the transformer TR1b is also the same, AC voltages each having reverse polarity which are obtained in the secondary winding N2 of the transformer TR1a and the secondary winding N2 of the transformer TR1b are applied to the terminal t10a and the terminal t10b of the cold cathode fluorescent lamp 10, respectively.

[0081] In this manner, according to the constitution of the fluorescent lamp driver 2 of the second embodiment, similar to the fluorescent lamp driver 1 of the first embodiment, the AC voltages each having reverse polarity can be applied to the respective terminals of the cold cathode fluorescent lamp 10 on the basis of the output of the one drive/control circuit 5. Namely, in this case also, effects similar to the case of the first embodiment can be attained.

[0082] Furthermore, FIG. 6 shows a constitutional example of a fluorescent lamp driver 3 as a third embodiment in the present invention. In this figure, the same reference numerals are also given to the parts functioning similarly to those previously described in FIG. 2 and a description thereof is omitted. Furthermore, in this case, the constitution of a drive/control circuit 5 is also similar to the one shown in FIG. 4. The fluorescent lamp driver 3 of the third embodiment is constituted such that the one drive/control circuit 5 drives a plurality of cold cathode fluorescent lamps. In this case, an example having two fluorescent lamps, the cold cathode fluorescent lamp 10 and a cold cathode fluorescent lamp 11, is illustrated.

[0083] Firstly, in the cold cathode lamp driver 3, a transformer TR2a and a transformer TR2b are added to the constitution shown in FIG. 2. These transformer TR2a and transformer TR2b are constituted so as to obtain characteristics equivalent to those of a transformer TR1a and a transformer TR1b, and the winding directions of primary winding N1 and secondary winding N2 thereof are the same. Furthermore, the transformer TR2a and the transformer TR2b are arranged to be located on both ends of the cold cathode fluorescent lamp 11.

[0084] In this case, as the primary winding N1 of the transformer TR2a, a winding start portion thereof is connected to the line from a winding start portion of primary winding N1 of the transformer TR1a to a winding end portion of primary winding N1 of the transformer TR1b side. Furthermore, a winding end portion of the primary winding N1 of this transformer TR2a is connected to the line from a winding end portion of the primary winding N1 of the transformer TR1a to a winding start portion of the primary winding N1 of the transformer TR1b. Namely, according to this arrangement, the relationship between the transformer TR1a and the transformer TR2a is in parallel, and the respective primary winding N1 is connected in the same direction with respect to the voltage supply source, thereby obtaining AC voltages having the same polarity.

[0085] Furthermore, as for primary winding N1 of the transformer TR2b, a winding start portion thereof is connected to the line from the winding end portion of the primary winding N1 of the transformer TR1a to the winding start portion of the primary winding N1 of the transformer TR1b. In addition, a winding end portion of the primary winding N1 of this transformer TR2b is connected to the line from the winding start portion of the primary winding N1 of the transformer TR1a to the winding end portion of the primary winding N1 of the transformer TR1b. Accordingly, while the transformer TR1a and the transformer TR2b also have the parallel relationship, the respective primary winding N1 is reverse in connecting direction, thereby obtaining AC voltages each having reverse polarity.

[0086] In addition, a winding start portion of the secondary winding N2 of the transformer TR2a is connected to a terminal t11a of the cold cathode fluorescent lamp 11, and a winding end portion thereof is connected to a grounding wire. Furthermore, a winding start portion of the secondary winding N2 of the transformer TR2b is connected to a terminal t10b of the cold cathode fluorescent lamp 11 and a winding end portion thereof is similarly connected to a grounding wire.

[0087] In the above-described manner, the respective primary winding N1 of the transformer TR1a and the transformer TR2a is the same in the connecting direction (with respect to the voltage supply source), thereby obtaining the AC voltages having the same polarity. In contrast, the respective primary winding N1 of the transformer TR1a and the transformer TR2b is reverse in connecting direction, thereby obtaining AC voltages each having reverse polarity. Accordingly, in the transformer TR2a and the transformer TR2b, the AC voltages each having reverse polarity can be obtained with respect to the respective winding N2. Namely, this allows the AC voltages each having reverse polarity to be applied to the terminal t11a and the terminal t11b of the cold cathode fluorescent lamp 11, respectively.

[0088] Here, the case based on the constitution in which the transformer TR1a and the transformer TR1b arranged at both ends of the cold cathode fluorescent lamp 10 are connected in parallel is taken as an example of the constitution in which the plurality of cold cathode fluorescent lamps are driven by the one drive/control circuit 5. However, a case based on the constitution in which the transformer TR1a and the transformer TR1b are in serial connection as shown in FIG. 5 can also employ the similar constitution. Namely, in this case, the winding start portion of the primary

winding N1 of the transformer TR2a is connected to the line from the winding end portion of the primary winding N1 of the transformer TR1a to the winding end portion of the primary winding N1 of the transformer TR1b as shown in FIG. 5. Furthermore, the winding end portion of the primary winding N1 of this transformer TR2a is connected to the line from the winding start portion of the primary winding N1 of the transformer TR1b to an emitter of a switching element Q2. Still further, the winding start portion of the primary winding N1 of the transformer TR2b is connected to the line from the winding start portion of the primary winding N1 of the transformer TR1b to the emitter of the switching element Q2, and the winding end portion of the primary winding N1 of the transformer TR2b is connected to the line from the winding end portion of the primary winding N1 of the transformer TR1a to the winding end portion of the primary winding N1 of the transformer TR1b.

[0089] Furthermore, while here, the constitution corresponding to the two cold cathode fluorescent lamps is exemplified, a constitution corresponding to three fluorescent lamps or more can be employed by connecting respective start and end portions of primary winding N1 of an additional transformer(s) TR to the lines connecting the respective start and end portions of the primary winding N1 of the transformer TR1a and the transformer TR1b in the same manner as described above.

[0090] Still further, in a case based on the constitution in FIG. 5, the respective start and end portions of the primary winding N1 of the additional transformer(s) TR may be similarly connected to the line connecting the respective winding end portions of the primary winding N1 of the transformer TR1a and the transformer TR1b and the line connecting the winding start portion of the primary winding N1 of the transformer TR1b and the emitter of the switching element Q2, respectively.

[0091] Also, in this case, the drive/control circuit 5 stabilizes a secondary winding current based on detection output by the current detection resistor R1 provided for the secondary winding N2 of the transformer TR1a. However, since the respective transformers TR have equivalent characteristics as described above, the stabilization control over the secondary winding current of each of the transformers TR can be performed similarly.

[0092] Here, in the above-described embodiments, after the primary winding N1 and the secondary winding N2 of the respective transformers TR are wound in the same direction, the respective primary winding N1 is connected to each other in such a manner that the connecting directions thereof are reverse with respect to the voltage supply source to obtain the AC voltages each having reverse polarity in the respective primary winding N1, thereby obtaining the AC voltages each having reverse polarity in the respective secondary winding N2. However, in place of this constitution, a constitution can be employed in which the respective primary winding N1 is connected in the same connecting direction to obtain the alternating voltages having the same polarity and then the primary winding N1 and the secondary winding N2 of either of the transformers TR are wound in a different direction, resulting in the AC voltages each having reverse polarity in the respective secondary winding N2.

[0093] As one example, while in the case of the constitution shown in FIG. 2, the winding end portions of the

respective primary winding N1 of the transformer TR1a and the transformer TR1b are connected to each other to obtain the AC voltages each having reverse polarity, the winding end portion of the primary winding N1 of the one transformer is connected to the winding start portion of the primary winding N1 of the other transformer to obtain the AC voltages having the same polarity and then, for example, in the transformer TR1b, the winding directions of the primary winding N1 and the secondary winding N2 are reversed. Accordingly, the AC voltage obtained in the secondary winding N2 on the transformer TR1b side has reverse polarity to the AC voltage obtained in the secondary winding N2 of the transformer TR1a side, so that the voltages each having reverse polarity are applied to the terminals t10a and t10b of the cold cathode fluorescent lamps 10, respectively.

[0094] Alternatively, the primary winding N1 on the transformer TR1a side and on the transformer TR1b side is caused to have the same polarity similarly, and then the winding directions of the primary winding N1 and the secondary winding N2 may be reversed on the transformer TR1a side.

[0095] In any one of the above-mentioned cases, the fluorescent lamp drivers of the embodiments only need to be constituted such that the AC voltages each having reverse polarity are consequently applied from both sides of the cold cathode fluorescent lamp by setting of the connecting directions of the primary winding N1 with respect to the voltage supply source (drive/control circuit 5) in the respective transformers TR or by setting of the winding directions of the primary winding N1 and the secondary winding N2 in each of the transformers TR.

[0096] Furthermore, while in the above-mentioned embodiments, as the constitution of the drive/control circuit 5, the cases in which the switching elements are driven in a separately excited manner are exemplified, a constitution of driving in a self-excited manner may be employed. Furthermore, as the switching elements, MOS-FET may be used instead of the transistors.

[0097] Furthermore, while in the above-mentioned embodiments, the cases where the fluorescent lamp driver drives the cold cathode fluorescent lamp are exemplified, a constitution of driving a hot cathode fluorescent lamp can be applied in the present invention. In addition, the fluorescent lamp driver of the present invention can also be preferably applied to other than the liquid crystal display apparatus.

[0098] It should be understood by those skilled in the art that various modifications, combinations, sub-combinations and alterations may occur depending on design requirements and other factors insofar as they are within the scope of the appended claims or the equivalents thereof.

What is claimed is:

1. A fluorescent lamp driver, comprising:

switching means that switches a DC power supply voltage, and

a first transformer and a second transformer configured to obtain AC voltages each having reverse polarity, as AC voltages excited from primary winding to secondary winding of the respective transformers, on the basis of output voltages of said switching means, wherein:

said first transformer and said second transformer are arranged to be located in the vicinity of both ends of said fluorescent lamp, and the AC voltage obtained in the secondary winding of said first transformer is applied to one terminal of said fluorescent lamp and the AC voltage obtained in the secondary winding of said second transformer is applied to the other terminal of said fluorescent lamp.

2. The fluorescent lamp driver as claimed in claim 1, wherein:

the primary wiring of said first transformer and the primary wiring of said second transformer are connected to said switching means so that the AC voltages obtained in the respective wirings have reverse polarity, and

wiring directions of the primary wiring and the secondary wiring of said first transformer and wiring directions of the primary wiring and the secondary wiring of said second transformer are arranged to be the same, respectively.

3. The fluorescent lamp driver as claimed in claim 1, wherein:

the primary wiring of said first transformer and the primary wiring of said second transformer are connected to said switching means so that the AC voltages obtained in the respective wirings have the same polarity, and

wiring directions of the primary wiring and the secondary wiring are arranged to be reversed in either one of said first transformer and said second transformer.

4. The fluorescent lamp driver as claimed in claim 1, further comprising:

switching driving means that drives said switching means in accordance with a required driving frequency; and

detecting means that detect a current level flowing through the secondary wiring of said first transformer or said second transformer, wherein:

said switching driving means is configured to control said driving frequency in accordance with the current level detected by said detecting means so as to stabilize the current level flowing through said secondary wiring.

5. The fluorescent lamp driver as claimed in claim 1, wherein:

a resonant capacitor is connected in series to both the primary wiring of said first transformer and the primary wiring of said second transformer.

6. The fluorescent lamp driver as claimed in claim 1, wherein:

said fluorescent lamp is provided in plural, and

a plurality of sets of said first transformer and said second transformer corresponding to the number of said fluorescent lamps are connected to said switching means.

7. A liquid crystal display apparatus having at least a liquid crystal panel and a backlight unit composed of a fluorescent lamp, having:

a fluorescent lamp driving unit for driving said fluorescent lamp to emit light comprising:

switching means that switches a DC power supply voltage, and

a first transformer and a second transformer configured to obtain AC voltages each having reverse polarity, as AC voltages excited from primary winding to secondary winding of the respective transformers, on the basis of output voltages of said switching means, wherein:

said first transformer and said second transformer are arranged to be located in the vicinity of both ends of said fluorescent lamp, and the AC voltage obtained in the secondary winding of said first transformer is applied to one terminal of said fluorescent lamp and the AC voltage obtained in the secondary winding of said second transformer is applied to the other terminal of said fluorescent lamp.

* * * * *

专利名称(译)	荧光灯驱动器和液晶显示装置		
公开(公告)号	US20050253536A1	公开(公告)日	2005-11-17
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[标]申请(专利权)人(译)	YOSHIKI OYAMA		
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摘要(译)

为了抑制高压施加到荧光灯时的漏电流以提高发光效率，本发明提供一种荧光灯驱动器，其包括切换直流电源电压的开关装置和第一变压器。第二变压器，其被配置为基于开关装置的输出电压，获得各自具有相反极性的AC电压，作为从各个变压器的初级绕组到次级绕组激励的AC电压，其中第一变压器和第二变压器是位于荧光灯两端附近的，并且在第一变压器的次级绕组中获得的AC电压施加到荧光灯的一个端子，并且在第二变压器的次级绕组中获得的AC电压应用于荧光灯的另一个端子。

