United States Patent

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[72] Inventors Shigeo Koyama
Neyagawa-shi;
Masao Yasuda, Higashiosaka-shi; Toru Takei, Osaka; Yasutaka Kawai, Higashiosaka-shi; Takeshi Matsushima, Nara-shi, all of Japan

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[73] Assignee Matsushita Electric Industrial Co., Ltd.
Kadoma-shi, Osaka, Japan
[32] Priorities Aug. 27, 1968
[33] Japan
[31] 43/74511;
Nov. 4, 1968, Japan, No. 43/97146

[54] **INSTANTANEOUS STARTER DEVICE FOR A DISCHARGE LAMP EMPLOYING A DIODE THYRISTOR**

4 Claims, 11 Drawing Figs.

[52] U.S. Cl. 315/101, 315/105, 315/205, 315/207, 315/239, 315/289, 315/DIG. 5

[51] Int. Cl. H05b 41/18
[50] Field of Search ..... 315/100 U, 100 H, DIG. 2, DIG. 5, 101, 105, 205, 207, 239, 289

[56] References Cited

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Primary Examiner—Roy Lake
Assistant Examiner—Siegfried H. Grimm
Attorney—Stevens, Davis, Miller & Mosher

ABSTRACT: A starter device for a discharge lamp instantaneously lighting a fluorescent discharge tube; connecting in parallel with said fluorescent discharge tube a starter circuit consisting of a pulse transformer, a capacitor, and a symmetrical diode thyristor or a reverse blocking diode thyristor having a breakover voltage V_{BO} lower than the rated power source voltage but higher than the tube voltage of said fluorescent discharge tube.

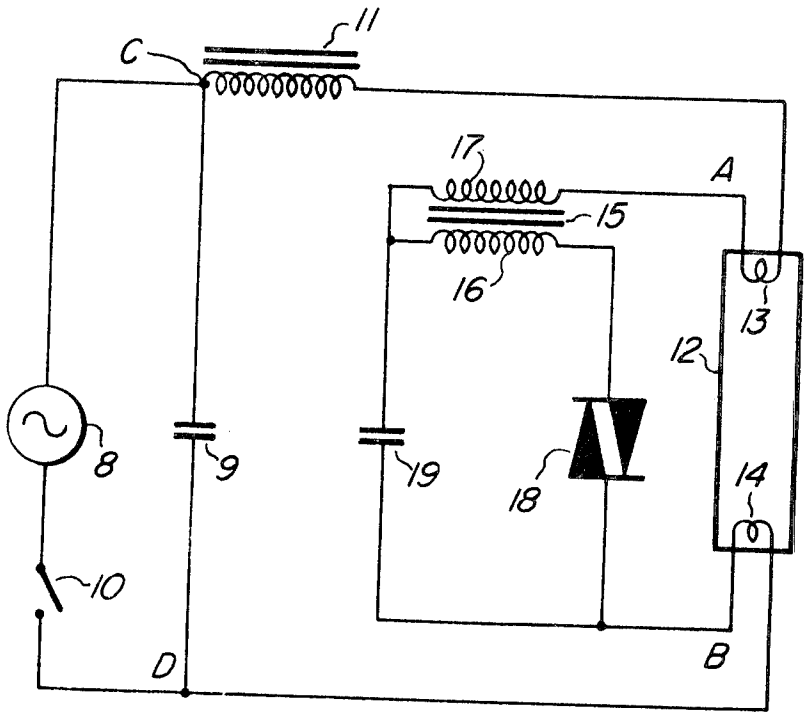


FIG. 1 PRIOR ART

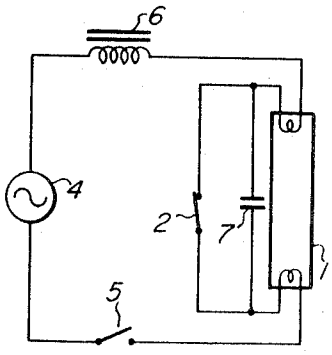


FIG. 2 PRIOR ART

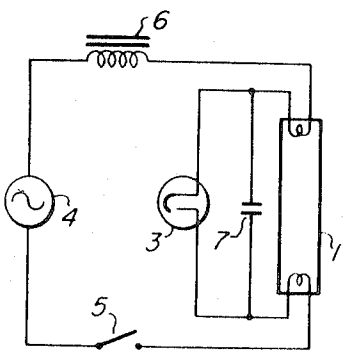
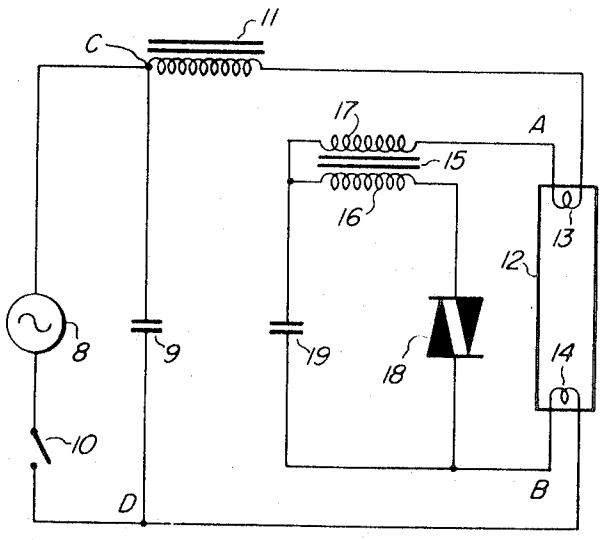


FIG. 3



S. KOYAMA, M. YASUDA, T. TAKEI, Y. KAWAI AND T. MATSUSHIMA

INVENTORS

BY Stevens, Davis, Miller & Mosher ATTORNEYS

FIG. 4

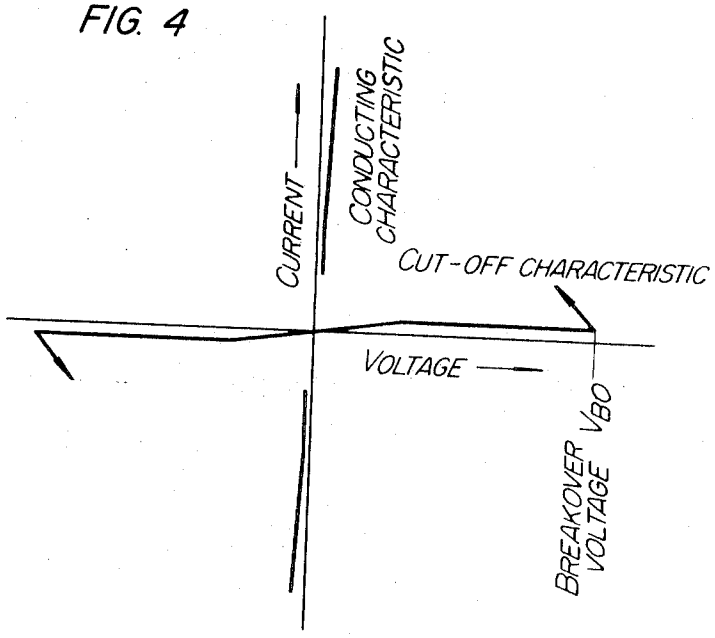

CURRENT
CONDUCTING CHARACTERISTIC
CUT-OFF CHARACTERISTIC
VOLTAGE
BREAKOVER VOLTAGE V_{BO}

FIG. 7

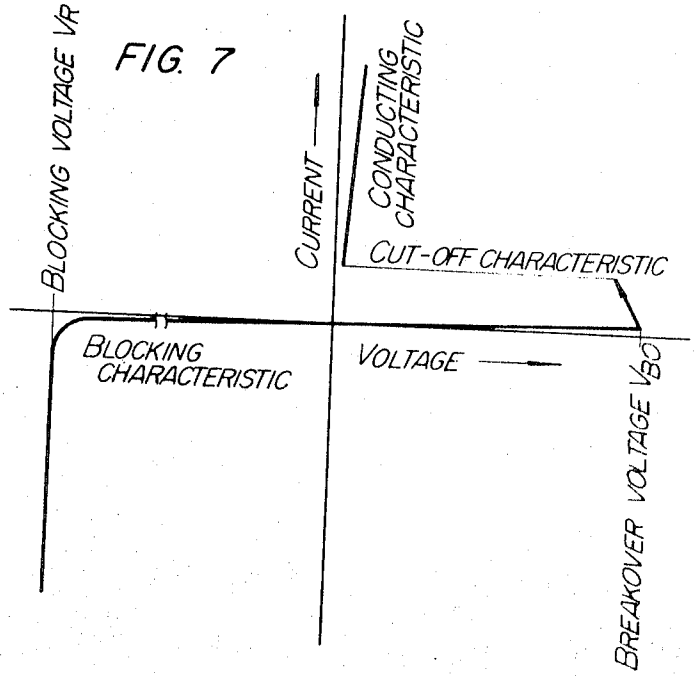

BLOCKING VOLTAGE V_R
CURRENT
CONDUCTING CHARACTERISTIC
CUT-OFF CHARACTERISTIC
BLOCKING CHARACTERISTIC
VOLTAGE
BREAKOVER VOLTAGE V_{BO}

FIG. 5

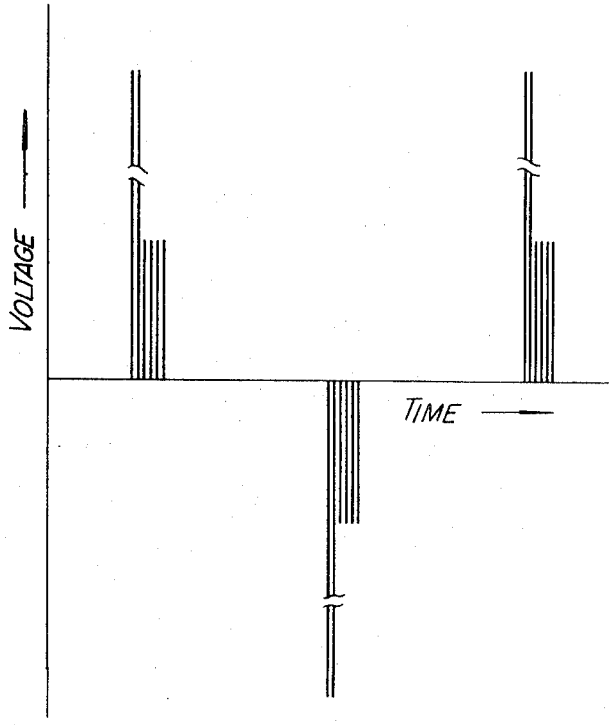


FIG. 6

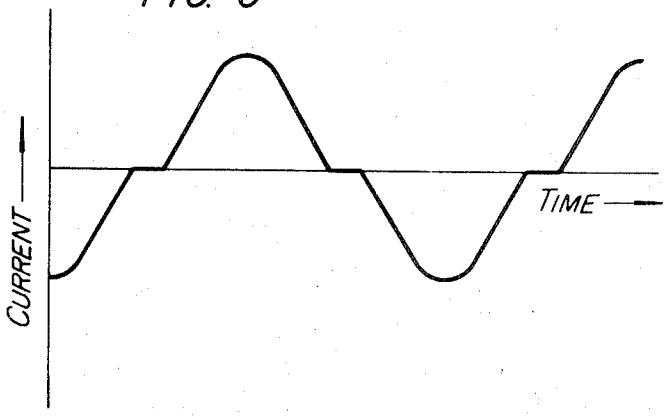


FIG. 8

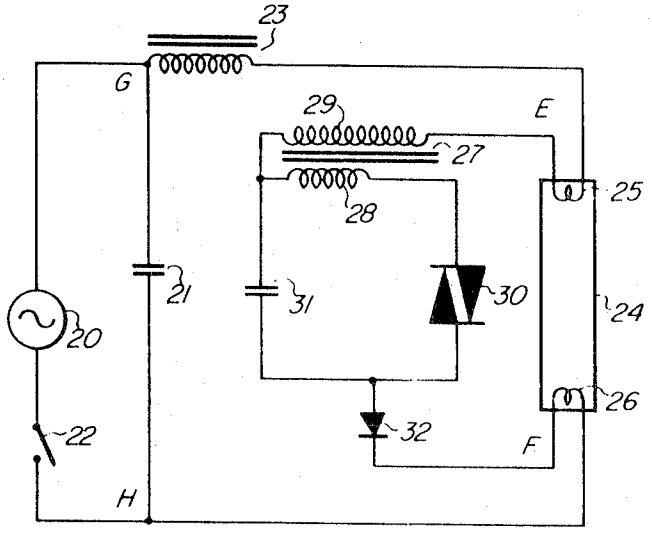

23
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FIG. 11

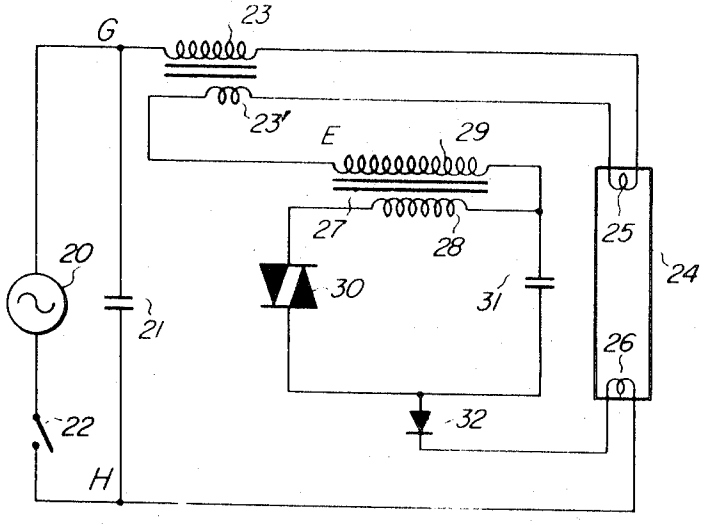

G
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FIG. 9

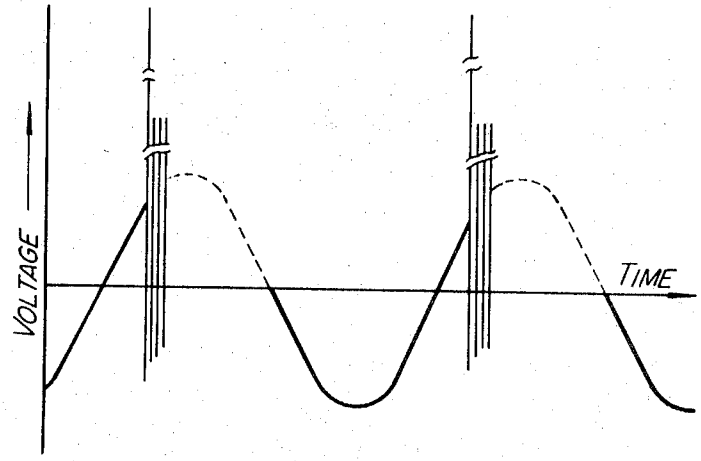
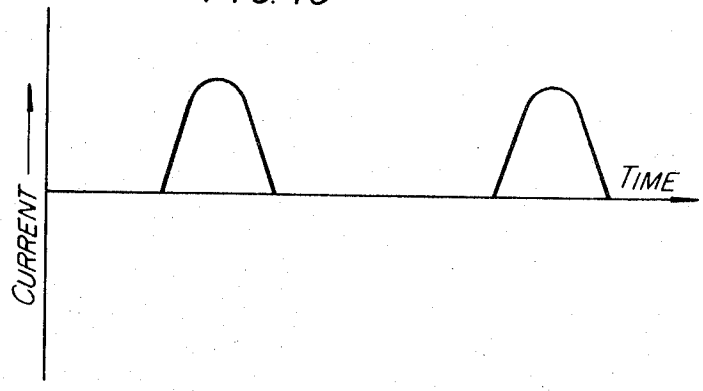


FIG. 10



INSTANTANEOUS STARTER DEVICE FOR A DISCHARGE LAMP EMPLOYING A DIODE THYRISTOR

The present invention relates to a starter device for a discharge lamp instantaneously lighting a fluorescent discharge tube; connecting in parallel with said fluorescent discharge tube a starter circuit consisting of a pulse transformer, a capacitor, and a symmetrical diode thyristor or a reverse blocking diode thyristor. Detailed explanation of the invention will be made hereinafter with reference to the accompanying drawings, in which;

FIGS. 1 and 2 are the electric circuit diagrams of prior art starter devices for a discharge tube.

FIG. 3 shows the electric circuit diagram of a starter device for a discharge tube according to one embodiment of the present invention.

FIG. 4 shows the voltage-current characteristic of a symmetrical diode thyristor used in the present invention.

FIG. 5 shows the voltage waveforms across the terminals A and B of the device shown in FIG. 3 during starting.

FIG. 6 shows the waveforms of the current flowing through the symmetrical diode thyristor or at the point A of the device shown in FIG. 3 during starting.

FIG. 7 shows the voltage-current characteristic of a reverse blocking diode thyristor used in circuit of FIG. 3 and 8 or 11.

FIG. 8 shows the electric circuit diagram of a starter device for a discharge tube according to another embodiment of the present invention.

FIG. 9 shows the voltage waveforms across the terminals A and B of the device shown in FIG. 8 during starting.

FIG. 10 shows the waveforms of the symmetrical diode thyristor or current flowing through the reverse blocking diode thyristor or at the point E of the device shown in FIG. 8 during starting.

FIG. 11 shows the practical electric circuit diagram of the circuit shown in FIG. 8.

A conventional starter device as shown in FIGS. 1 and 2 consists of a manual switch 2 or a glow switch 3 connected in parallel with kyv wl[pescent 4ischarge lamp , The anual switch is inconvenient because it requires much time before starting while a glow switch has the problem of a short lifetime although the starting time is faster. In these figures, 4 is an AC source, 5 is a power source switch, 6 is a current limiting ballast and 7 is a noise preventing capacitor connected in parallel with the manual switch 2 or the glow switch 3. Generally, in order to instantaneously start a fluorescent discharging tube it is necessary to provide a sufficient preheating current to both cathodes and at the same time a high continuous or a pulse voltage enough to light the tube between the opposite cathodes. In the prior art this is attained by winding a cathode preheating winding or a high-voltage applying winding. However, these methods lead to an increase in the size and weight of the current limiting ballast. The efficiency is reduced due to an increase in the internal loss. Further, the high cost lowers the commercial advantage.

Therefore, this invention is aimed at removing the above-mentioned defects of the prior art and provides a novel starter device for a discharge tube. An embodiment of this invention will be explained with reference to FIGS. 3 to 7 hereinafter. In FIG. 3, 8 is an AC power source, 9 is a noise preventing capacitor, 10 is a power source switch, 11 is a current limiting ballast, 12 is a fluorescent discharge tube, both terminals of which have cathodes 13 and 14, 15 is a pulse transformer for generating a pulse voltage consisting of a primary winding 16 and a secondary winding 17, 18 is a symmetrical diode thyristor, and 19 is a capacitor for generating a pulse voltage. The symmetrical diode thyristor 18 has a switching characteristic as shown in FIG. 4. Namely, at a certain voltage (breakover voltage V_{BO}) the symmetrical diode thyristor rapidly changes from the cutoff state to the conducting state. In this circuit, the noise preventing capacitor 9 is connected in parallel with the power source 8 through the power source switch 10, one end of the power source 8 being connected to one end of the cathode 13 of the discharge tube 12 through the current limiting ballast 11 while the other end of the power source 8 is connected to the one end of another cathode 14 of the discharge tube 12 through the power source switch 10. The other end of the cathode 13 is connected to one end of the secondary winding 17 of the pulse transformer 15. The other end of the secondary winding 17 is connected to one end of the primary winding 16 and also to one end of the capacitor 19. The number of turns of the secondary winding 17 is larger than that of the primary winding 16 i.e. at a ratio of about 10:1. The other end of the primary winding 16 of the pulse transformer 15 is connected to one end of the symmetrical diode thyristor 18. The other end of a capacitor 19 is connected to the other end of the symmetrical diode thyristor 18 and connected to the other end of the cathode 14 of the discharge tube 12. Here, it is necessary that the primary and secondary windings 16 and 17 of the pulse transformer 15 be wound in the same direction.

The breakover voltage V_{BO} of the symmetrical diode thyristor used in the present invention has the characteristic; the rated output voltage of the power source 8 > the breakover voltage V_{BO} > the tube voltage of the discharge tube 12.

Next, the circuit operation will be explained in detail. In the circuit of FIG. 3, when the power source switch 10 is closed and the conducting state is reached, a voltage higher than the breakover voltage V_{BO} i.e. the rated output voltage of the power source 8 is applied across both terminals of the symmetrical diode thyristor 18. Thus, the symmetrical diode thyristor 18 breaks over to make the circuit conductive. A sufficiently large preheating current flows through the cathodes 13 and 14 of the fluorescent discharge tube 12. In this case the breakover of the symmetrical diode thyristor 18 is determined by the breakover voltage V_{BO} while the cutoff thereof is determined by a current flowing therethrough. Due to the inductance of the current limiting ballast 11 the current lags behind the voltage so that the symmetrical diode thyristor becomes conductive over substantially the whole period of the cycle and the power source 8. The voltage waveforms between the points A and B of the cathodes 13 and 14 become as shown in FIG. 5 while the waveforms of the current flowing through the thyristor 18 during preheating becomes as shown in FIG. 6. A high pulse voltage (about 600 V) as shown in FIG. 5 is applied between both terminals of the discharge tube 12 and the preheating of the cathode strikes the discharge of the fluorescent tube 12. Once the discharge tube 12 is lit, the voltage appearing across the symmetrical diode thyristor 18 becomes equal to the tube voltage of the discharge tube 12 so that the symmetrical diode thyristor 18 becomes cutoff. Thus, the discharge tube 12 is maintained in the discharge state. However, during the lighting of the discharge tube 12 the waveform of the tube voltage has high peak values by the influence of the charge and discharge of the capacitor 19. This is enhanced particularly at low temperatures, and occasionally the peak value of the tube voltage exceeds the breakover voltage V_{BO} of the symmetrical diode thyristor 18. Thus, even though the discharge tube 12 is lighted and the symmetrical diode thyristor 18 is cutoff, the thyristor recovers its conducting state. As a result, the discharge tube 12 returns to the preheating state and does not commence lighting. In the practical circuit for the purpose of preventing this inconvenience a resistor (not shown) is connected in parallel with the symmetrical diode thyristor 18 or the capacitor 19. By the insertion of this resistor the discharge voltage of the capacitor at each cycle is absorbed and hence the waveform of the tube voltage during lighting is improved. No reignition phenomenon of the symmetrical diode thyristor 18 takes place at low temperatures. Although in the above embodiment has been made of a symmetrical diode thyristor having the characteristic that the cutoff state rapidly changes to the conducting state at a certain voltage (i.e. breakover voltage V_{BO}), a reverse blocking diode thyristor having a high blocking power at a negative voltage as shown in FIG. 7 can be used. The breakover voltage V_{BO} of the reverse blocking diode thyristor used here satisfies the condition; the rated output voltage of the power source >

breakover voltage V_{BO} > the tube voltage of the discharge tube, whereas the blocking voltage V_R is sufficiently larger than the rated power source voltage. When this reverse blocking diode thyristor is used, a pulsating current flows only in one direction of the circuit. Since a DC component is superposed on this pulsating current, the magnetic circuit of the current limiting ballast saturates so that the fluorescent discharge tube is preheated enough to be lit. The half wave of the power source blocked by the thyristor is applied across the cathodes of the discharge tube. As a result, the same effect can be obtained as in the case of a symmetrical diode thyristor. Furthermore, in the above embodiment a noise preventing capacitor **9** is inserted between the input side of the current limiting ballast **11** and the output side of the cathode **14** of the fluorescent discharge tube **12**, i.e. between the points C and D as shown in FIG. **3** in order to obtain the noise preventing effect. The same effect can be obtained when the capacitor is inserted between the points A and B. The thyristor **18** and capacitor **19** may be replaced by each other.

Next, a modified circuit based on the circuit system of FIG. **3** will be explained with reference to FIGS. **8** to **10**. In FIGS. **8**, **20** is a power source, **21** is a noise preventing capacitor, **22** is a power source switch, **23** is a current limiting ballast, **24** is a fluorescent discharge tube having cathode **25** and **26** on both sides thereof, **27** is a pulse transformer for generating a pulse voltage consisting of a primary winding **28** and a secondary winding **29**, **30** is a symmetrical diode thyristor, **31** is a capacitor for generating a pulse voltage, and **32** is a diode. The symmetrical diode thyristor **30** has a switching characteristic as shown in FIG. **4**. Namely at a certain voltage (breakover voltage V_{BO}), the symmetrical diode thyristor rapidly changes from the cutoff state to the conducting state. In this circuit construction the noise preventing capacitor **21** is connected in parallel with the power source **20** through the power source switch **22**. One end of the power source **20** is connected to one end of the cathode **25** of the discharge tube **24** through the current limiting ballast **23** while the other end of the power source **20** is connected to one end of the other cathode **26** of the discharge tube **24** through the power source switch **22**. The other end of the cathode **25** is connected to one end of the secondary winding **29** of the pulse transformer **27**. The other end of the secondary winding **29** is connected to the end of the primary winding **28** and together to one end of the capacitor **31**. The number of turns of the secondary winding **29** of the pulse transformer **27** is larger than that of the primary winding **28** in the ratio of about 10:1. One end of the symmetrical diode thyristor **30** is connected to the other end of the primary winding **28** of the pulse transformer **27**. The other end of the capacitor **31** is connected to the other end of the symmetrical diode thyristor **30** and the positive electrode side of the diode **32**. The negative electrode side of the diode **32** is connected to the other end of the other cathode **26** of the discharge tube **24**. Here the diode **32** may be connected in the reverse direction.

The breakover voltage V_{BO} of the symmetrical diode thyristor **30** used in this invention has the characteristic; the rated output voltage of the power source **20** > breakover voltage V_{BO} > the tube voltage of the discharge tube **24**. The reverse breakover voltage of the diode **32** is sufficiently larger than the rated output voltage of the power source **20**.

Next the circuit operation will be explained in detail. In the electric circuit shown in FIG. **8**, when the power source switch **22** is closed and the conducting state is reached, a higher voltage than the breakover voltage V_{BO}, i.e. the rated output voltage of the power source **20**, is applied between both terminals of the symmetrical diode thyristor **30**. Thus, the symmetrical diode thyristor **30** breaks over to make the circuit conductive. A preheating current from the cathodes half wave rectified by the diode **32** flows through the cathodes **25** and **26** of the fluorescent discharge tube **24**. The voltage waveform applied between the points E and F of the cathodes **25** and **26** of the fluorescent discharge tube **24** during preheating becomes as shown in FIG. **9** while the waveform of the current flowing through the thyristor **30** during preheating becomes as shown in FIG. **10**. A high pulse voltage as shown in FIG. **9** appears between both terminals of the discharge tube **24** i.e. between the cathodes **25** and **26**. So, due to the preheating effect of the cathodes **25** and **26** the discharge tube **24** is effectively lit. Once the discharge tube **24** is lit, the voltage appearing across the symmetrical diode thyristor **30** becomes cutoff. Therefore, the discharge tube **24** maintains the discharge state. Here even if the peak value of the tube voltage waveform of the discharge tube **24** is extremely high or has a large temperature dependence, the capacitor **31** is charged only in the DC direction by the diode **32**. Therefore, the bad influence on the peak value of the discharge tube **24** due to the charge and discharge of the capacitor **31** and on the symmetrical diode thyristor **30** can be prevented.

Although in the above embodiment explanation has been made of the case where one end of the secondary winding **29** of the pulse transformer **27** (i.e. the beginning of the winding) is connected to one end of the cathode **25** of the discharge tube **24** and the other end (i.e. the end of the winding) is connected to one end of the primary winding (i.e. the end of the winding), there is no trouble when the secondary winding is connected in the opposite direction. However, it is necessary that the secondary winding **29** and the primary winding **28** are connected in the same direction. Further, it is allowed that the symmetrical diode thyristor **30** and the capacitor **31** are reversely connected.

Although in the embodiment shown in FIG. **8** explanation has been made of a case where the starting element is a symmetrical diode thyristor, a reverse blocking diode thyristor having the characteristic as shown in FIG. **7** may be employed. The breakover voltage of the reverse blocking diode thyristor satisfied the condition; the rated output voltage of the power source > breakover voltage V_{BO} > the tube voltage of the discharge tube, whereas the blocking voltage V_R is sufficiently larger than the rated power source voltage. The current flowing through the circuit in the case of the reverse blocking diode thyristor is a pulsation current in one direction superposed on a DC current. Therefore, the magnetic circuit of the current limiting ballast becomes saturated and the fluorescent discharge tube is preheated enough to be lit. The half wave of the power source blocked by the thyristor is applied across the cathodes of the discharge tube. As the result, the same effect can be obtained as in the case with the symmetrical diode thyristor. It is needless to say here that the reverse blocking diode thyristor is connected in the same direction as the diode. Furthermore, in the above embodiment the noise preventing capacitor **21** inserted between the input side of the current limiting ballast **23** and the output side of the cathode of the discharge tube **24**, i.e. between the points G and H has the effect of preventing the noise.

FIG. **11** shows a circuit diagram where winding **23'** for increasing the cathode preheating current is employed together with the current limiting ballast **23** of FIG. **8**.

In the starter device of the present invention constituted as mentioned above, the addition of such auxiliary means fitted to the starting device to further improve the starting characteristic, i.e. the winding wound around the current limiting ballast for increasing the cathode preheating current shown in FIG. **11** and the existence of the adjacent conductor near the discharge tube, does not needless to say depart from the spirit of this invention.

Thus, the inventive use of the symmetrical diode thyristor or reverse blocking diode thyristor as the starter element for lighting the discharge tube has a semipermanent life due to the semiconductor and a much more miniaturized size compared to the conventional glow starter device. Therefore, the weight can be reduced. Since no large current limiting ballast is used, the internal loss is diminished. In addition, more rapid starting is effected.

What is claimed is:

1. A starter device for a fluorescent discharge lamp having first and second cathodes, each of said cathodes having first and second ends, comprising

a. a current limiting ballast connected in series with an electric power source between the first ends of said first and second cathodes,

b. a pulse transformer having primary and secondary windings wound in the same direction, each of said windings having first and second ends,

c. first conductive means coupling a first end of the secondary winding of said transformer to the second end of said first cathode, the second end of said secondary winding being connected to the second end of said primary winding,

d. a reverse blocking diode thyristor,

e. a capacitor coupled in series with said thyristor across the primary winding of said transformer, and

f. second conductive means coupling the junction of said thyristor and capacitor to the second end of said second cathode.

2. A starter device as defined by claim 1 wherein said second conductive means comprise a diode.

3. A starter device for a fluorescent discharge lamp having a first and second cathodes, each of said cathodes having first and second ends, comprising

a. a current limiting ballast connected in series with an electric power source between the first ends of said first and second cathodes,

b. a pulse transformer having primary and secondary windings wound in the same direction, each of said windings having first and second ends,

c. first conductive means coupling a first end of the secondary winding of said transformer to the second end of said first cathode, the second end of said secondary winding being connected to the second end of said primary winding,

d. a symmetrical diode thyristor,

e. a capacitor coupled in series with said thyristor across the primary winding of said transformer, and

f. a diode only coupling the junction of said thyristor and capacitor to the second end of said second cathode.

4. A second device as defined by claim 3 wherein said first conductive means comprises an auxiliary winding inductively coupled to said current limiting ballast.

* * * * *