# United States Patent

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[54] **GAS DISCHARGE LAMP FIRING CIRCUIT**


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[51] **Int. Cl.** .....**H05b 41/32**

[58] **Field of Search**...315/183, 224, 219, 234, 209 S, 315/209 P, 241 S, 241 P, 235, 240, 173



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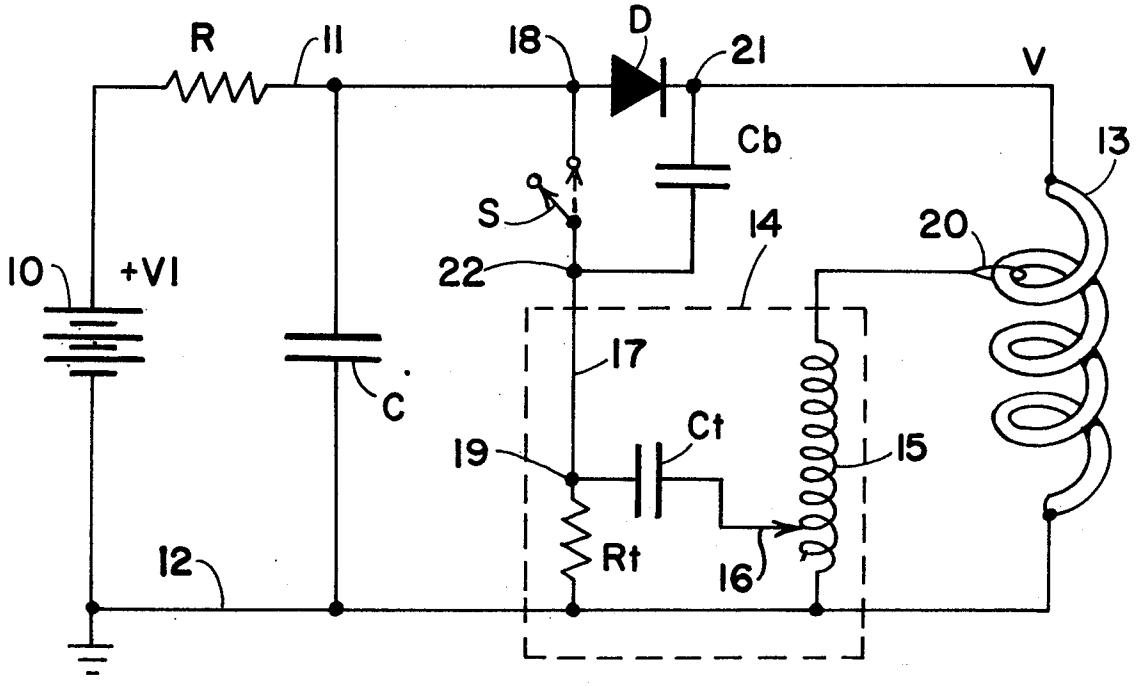
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[57] **ABSTRACT**

A voltage boosting means is provided in a stroboscopic lamp firing circuit for momentarily substantially increasing the available voltage for firing the lamp at the precise point in time that the normal striking means is operated to ready the lamp for firing. The momentary substantial increase in voltage for firing the lamp is provided by a capacitor which is charged to or partly to the normal firing voltage prior to initiation of the striking means for the lamp. A switch means utilized to initiate the striking means also serves to apply a voltage to one side of the capacitor to thereby momentarily substantially increase the voltage on the other side of the capacitor relative to ground. Since the boosted voltage occurs precisely upon operation of the switch means which operation also operates the striking means, the substantially increased voltage is provided at the proper time for assuring firing of the lamp.


**3 Claims, 4 Drawing Figures**



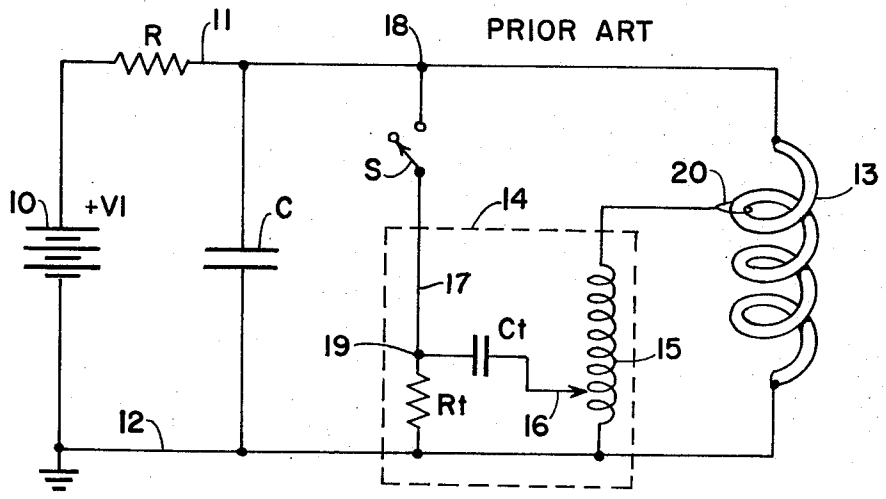



FIG. 1

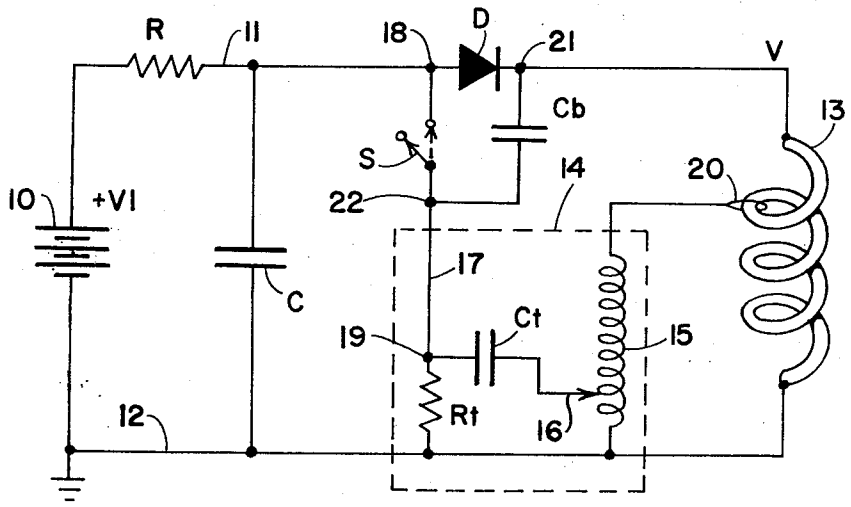



FIG. 2

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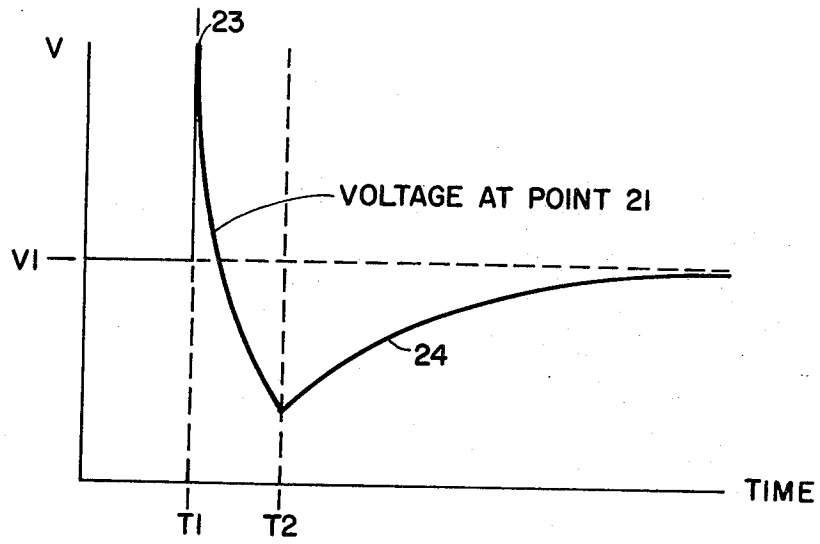



FIG. 3

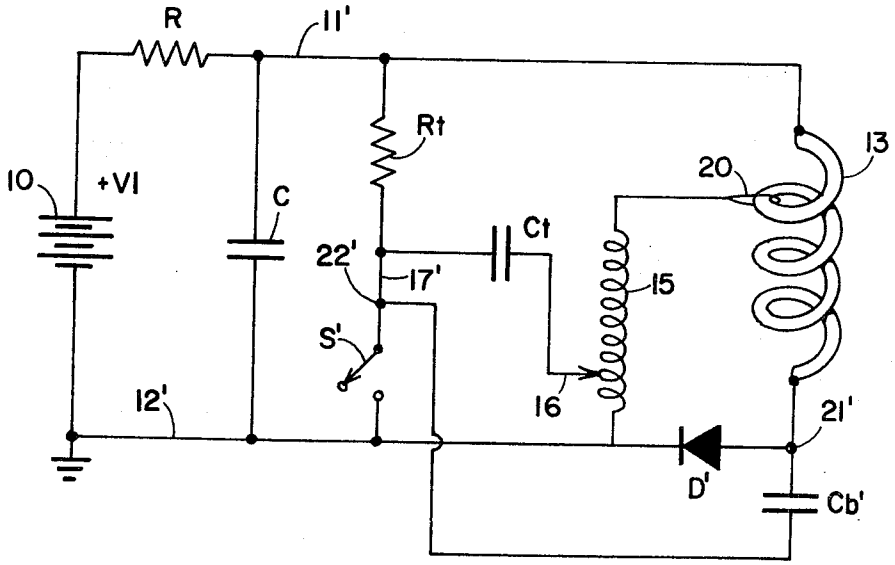



FIG. 4

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# GAS DISCHARGE LAMP FIRING CIRCUIT

This invention relates generally to stroboscopes and more particularly, to a novel stroboscopic lamp firing circuit for greatly increasing the reliability of operation of the lamp.

## BACKGROUND OF THE INVENTION

Stroboscopic lighting is well known in the art and has a wide range of uses. Essentially, a stroboscope incorporates a gas discharge lamp capable of emitting an extremely intense flash of light for an extremely short time duration. The firing circuit for the lamp is generally designed such that the lamp can be successively fired at various repetition rates or frequencies or, fired only once at a desired instant in time. In fairly sophisticated stroboscopic lamp circuits, extremely accurate repetition rates can be achieved and the lamp itself is thus useful in timing operations; for example, in monitoring moving machine parts. In simpler versions, a stroboscopic lamp is very useful in photography for taking flash pictures wherein the lamp need only be flashed once at a given instant in time. In still other versions, a relatively simple circuit can be provided for flashing the lamp at a relatively low frequency such as from one to 30 times per second and wherein the particular frequency and phasing of the flashing is not of primary importance. This type of lamp is useful for psychedelic lighting effects.

The present invention is primarily concerned with the foregoing types of stroboscopic lamps wherein a fairly simplified and economical firing circuit may be provided. However, it is to be understood that the invention is applicable to all types of stroboscopic lamps.

Essentially, the firing circuit for such lamps includes a voltage source which may constitute a battery when the lamp is to be employed in photography connected to charge a storage capacitor through a resistance. The lamp is connected across the capacitor and when not operated presents a very high resistance so that the source voltage can readily be stored on the capacitor. The circuit is completed by a striking means which generally takes the form of a high step-up transformer capable of applying a trigger pulse which serves to strike a small arc within the lamp; that is, effect at least a partial ionization of the gas in the lamp. If the voltage across the storage capacitor and thus across the lamp is sufficient to fire the lamp, the gas suddenly becomes highly ionized and the resistance of the lamp becomes very low. As a result, a very high current is drawn through the lamp from the storage capacitor and the desired high intensity flash from the lamp results. Discharge of the power on the storage capacitor through the lamp reduces the voltage from the source across the lamp to a low value so that the lamp extinguishes itself. At this point, the lamp again presents a very high resistance and the storage capacitor can then become recharged through the resistance and the circuit is ready for a subsequent firing. The maximum repetition rate of firing is thus determined in part by the time constant of charging of the storage capacitor since it is essential that the storage capacitor be sufficiently charged before a subsequent firing to provide the necessary voltage to fire the lamp.

One of the major problems in the foregoing types of circuits is the assuring that a sufficient voltage from the



voltage source exists across the lamp at the time of striking of the lamp. In the case of portable stroboscopic lighting units wherein batteries are often used for the voltage source, the available voltage for firing the lamp generally decreases over prolonged use simply as a result of degradation of the batteries. Thus reliability of firing of the lamp is impaired. In addition, physical changes take place in the lamp itself such that increased voltages are necessary to fire the same over those necessary when the lamp is first used. Many other factors may also determine whether or not a sufficient voltage is available to fire the lamp.

In order to increase reliability of stroboscopes, the first step has been to assure that a sufficient voltage is available to fire the lamp at the time of striking of the lamp. Assurance of a sufficient voltage has sometimes been accomplished in the past by utilizing a step-up transformer between the voltage source and the lamp itself. However, this involves additional circuit elements and oftentimes will require more expensive type storage capacitors. Even under these circumstances, the storage capacitor itself can be damaged from too much voltage. It would be highly desirable to provide some means for assuring that sufficient voltage is available with present day circuits employed in the more simplified versions of stroboscopic lighting all to the end that economy can be realized in the manufacture of such stroboscopic systems and yet the desired increased reliability of operation can be assured.

## BRIEF DESCRIPTION OF THE PRESENT INVENTION

With the foregoing considerations in mind, it is a primary object of the present invention to provide an improved gas discharge lamp firing circuit wherein a voltage of higher value than that normally appearing on the storage capacitor is applied to the lamp at the time of striking of the lamp wherein this higher voltage is derived from the normal voltage source already available in the lamp circuit, all to the end that a greatly increased reliability of operation is assured.

Briefly, the foregoing is accomplished by incorporating elements in the firing circuit in the form of booster means for raising the voltage from the source means for firing the lamp in response to the initiating means for operating the striking circuit for the lamp. The result is that a momentarily substantially increased voltage is provided across the lamp at the point in time of striking of the lamp to thereby effect complete ionization and sufficiently lower the resistance of the lamp that power from the storage capacitor can be assured of passing through the lamp. In the preferred embodiment of the invention, the booster means takes the form of a single additional booster capacitor to the circuit and a cooperating diode. The arrangement is such that the booster capacitor is charged from the voltage source through the diode to a given voltage normally sufficient for firing the lamp. The other side of the booster capacitor is connected to the initiating means for the striking circuit in such a manner that when this initiating means is operated to strike the lamp, the available voltage from the storage capacitor is applied to the other side of the booster capacitor thereby momentarily boosting the voltage appearing on the first side relative to ground. The diode prevents back flow of current

from the charged booster capacitor through the initiating means to the firing circuit so that the boosted voltage is applied across the lamp at the precise point in time of striking of the lamp. The result is an assurance of complete ionization of the gas in the lamp so that the energy stored in the storage capacitor can readily discharge through the lamp.

The advantages of the foregoing arrangement are numerous. First, by utilizing the booster means, a higher voltage type of lamp can be used with a lower voltage circuit. Further, if the condition of the lamp is such that an increased voltage across it is necessary to fire the same, the lamp can still be fired reliably even though the voltage across the storage capacitor is not sufficient to fire the lamp. Thus the useful life of the lamp can be substantially increased.

Moreover, for a given time constant of recharge of the storage capacitor, a faster flash repetition rate can be achieved since it is not essential that the storage capacitor be completely charged at the time of firing in view of the presence of the boosted voltage. Alternatively, for a given flash repetition rate, a longer time constant of recharge for the storage capacitor can be used.

Since it is possible to use a lower source voltage, batteries become more practical in a portable system. Moreover, the breakdown voltage rating of the storage capacitor can be lower for a given lamp. Step-up transformers or voltage doubling circuits as heretofore thought necessary can also be eliminated. There are many other advantages that result from the improved circuit of the invention.

## BRIEF DESCRIPTION OF THE DRAWINGS:

A better understanding of the invention will be had by now referring to the accompanying drawings, in which:

FIG. 1 represents a typical simplified prior art type of stroboscopic lamp and firing circuit therefor;

FIG. 2 illustrates the same circuit as FIG. 1 but incorporating the voltage boosting means of the present invention;

FIG. 3 is a qualitative plot of voltage values during a firing of the lamp appearing at one of the lamp terminals useful in explaining the operation of the invention; and,

FIG. 4 is a modified circuit in accordance with the invention.

## DETAILED DESCRIPTION OF THE INVENTION:

Referring to FIG. 1, there is illustrated a simplified stroboscopic lighting circuit including a battery 10 connected across a storage capacitor C through a charging resistance R by way of leads 11 and 12. A gas discharge lamp 13 which may be of the xenon type also connects across the leads 11 and 12 so that voltage stored on the capacitor C appears across the lamp 13.

A striking circuit enclosed within the dashed outline 14 includes a transformer 15. The primary of the transformer coil 15 connects through tap 16 and condenser Ct to a lead 17 arranged to be energized from the voltage source in the form of the battery 10 and storage capacitor C through a switch means S when closed to a junction point 18 in the lead 11. A high discharge resistance Rt connects between the junction point of the lead 17 and condenser Ct and the lead 12. The secondary of the transformer 15 terminates in a coil 20 surrounding the lamp 13.

The foregoing elements are entirely conventional. The switch means S, while shown as a simple mechanical type switch, may constitute electrical contacts to be closed as in the case of a photographic strobe lamp circuit or may constitute any type of electronic switch such as a vacuum tube, solid state element, or other equivalent means for closing the circuit between the junction points 18 and 19.

In the operation of the circuit of FIG. 1, assume that the switch means S is open as shown. Under these conditions, the voltage V1 of the battery 10 will result in a current flow through the resistance R to charge the capacitor C. The resistance of the lamp 13 when it is not fired, is extremely high so that the voltage stored across the capacitor C will correspond substantially to V1. This same voltage will also appear across the lamp 13 by way of the leads 11 and 12.

The switch S essentially constitutes an initiating means for the striking circuit 14. When the switch S is closed, the voltage V1 will be applied to the junction point 19 and capacitor Ct. Since the voltage across a capacitor cannot change instantaneously, the same V1 volts will energize the primary of the transformer 15 through the tap 16 in the form of a transient or high rate of change voltage as the capacitor Ct charges. This changing voltage in the primary will be reflected in an extremely large voltage generated in the secondary of the coil 15 in accord with the step-up ratio of the turns. The high secondary voltage will be applied to the coil 20 and result in the striking of a small arc in the gas in the lamp 13; that is, at least a partial ionization of the gas will occur. At this point, the voltage across the storage capacitor C appears across the lamp 13, and if sufficiently high, will cause an avalanching of the ionization and a discharging of the stored energy through the lamp.

The discharge through the lamp 13 results in a highly intense flash of light. Since the resistance of the lamp 13 is dropped to an extremely low value, the discharge from the storage capacitor C is extremely rapid, and the voltage across the lamp drops to a relatively low value so that the lamp is extinguished.

When the lamp has completed its firing, it will assume its former very high resistance value so that the storage capacitor C will then commence recharging through the resistance R. If the switch S should remain closed, the small striking circuit capacitor Ct will also be charged to the voltage value V1 and the lamp cannot be refired until the switch is opened so that the striking circuit capacitor Ct can discharge through Rt. After the striking circuit capacitor Ct has completed its discharge, reclosing of the switch S will result in a subsequent firing of the lamp 13.

The condition of firing of the lamp 13 in the above described operation is that the voltage V1 from the voltage source across the lamp be of a sufficient value to fire the lamp when the striking circuit operates. This "sufficient voltage," as mentioned heretofore, depends on the lamp involved. If the voltage source in the form of the battery V1 provides a voltage just sufficient to fire the lamp, it is very possible after prolonged use that the voltage will degrade as a consequence of aging of

the battery to a value in which the lamp will not fire. Alternatively, and as also described heretofore, repeated use of the lamp can result in the necessity of a higher firing voltage with age of the lamp. Thus, in the circuit of FIG. 1 unless some type of very high initial voltage source is provided, the reliability of firing of the lamp is subject to the foregoing conditions.

Referring now to FIG. 2, assurance of a sufficient voltage across the lamp at the point in time of striking of the lamp is realized by providing a momentary increased voltage from the voltage source at the lamp terminal or junction point 21 in the lead 11. This voltage booster means takes the form of a small booster capacitor *Cb* connected between the lamp terminal at the point 21 and the lead 17 at a junction point 22 between the switch means and the striking circuit 14. Cooperating with this small booster capacitor is a diode D connected between the point 21 of connection of the capacitor to the lamp terminal and the junction of the switch means S with the voltage storage capacitor making up part of the the battery 10 and resistance R.

With the foregoing additional elements in the circuit, substantially higher than the normally available voltage across the lamp is momentarily provided at the instant of striking of the lamp.

The foregoing is depicted in FIG. 3, wherein the wave form of the voltage at the junction 21 during a firing operation is shown. Thus, at the moment of closing of the switch S depicted by the vertical line T1 the peak voltage at the point 21 is indicated at 23. This voltage is more than sufficient to assure firing of the lamp 13 so that discharge from the storage capacitor will take place through the lamp to the point in time designated by the vertical line T2. At this point, the voltage across the lamp is sufficiently low that the lamp is extinguished. The portion of the curve 24 represents the charging of the storage capacitor C. The time interval between T1 and T2 is greatly exaggerated in FIG. 3 for purposes of clarity. Actually, this time interval represents the duration of the flash of the lamp and in practice could be of the order of milliseconds or microseconds.

FIG. 4 illustrates a slightly modified circuit from that shown in FIG. 2. In this respect, the same numerals have been employed to designate corresponding components as in FIG. 2. However, in FIG. 4 the diode has been reversed and is designated D'. This diode connects between the junction of the lower lamp terminal and the capacitor *Cb'*, the terminal itself being designated 21'. The resistance Rt in the striking circuit in turn connects from the positive side of the circuit indicated by the numeral 11' rather than the ground side as described heretofore. The switch S' in turn is arranged to connect one side of the capacitor *Cb'* to the ground line 12' when closed. With this arrangement, the boosted voltage is boosted in a negative sense so that the voltage across the lamp at the time of striking is again substantially increased.

## OPERATION

The operation of the circuit of FIG. 2 providing the desired results depicted in FIG. 3 will now be described. Assume first that the switch S is open as shown by the solid lines in FIG. 2. Under these conditions, the storage capacitor C will again be charged up to the voltage V1 through the charging resistance R. The voltage stored across the capacitor will also appear across the capacitor Cb so that the upper side of the capacitor connected at point 21 will assume substantially a voltage of V1. The capacitor Cb is substantially smaller than the storage capacitor C. The same voltage V1 will thus appear across the lamp 13.

This quiescent situation is depicted by the initial horizontal portion of the curve of FIG. 3 between 0 and the time T1 the voltage being designated V1. If now the switch S is closed to the dotted position shown in FIG. 2, the stored voltage value on the lead 18 from the battery and capacitor will immediately be applied to the other side of the small capacitor Cb. Since the voltage across a capacitor cannot change instantaneously, the upper side of the capacitor will jump up to substantially twice the initial voltage applied thereto since the same initial voltage has been applied to the other side of the capacitor. The point 21 will thus exhibit a momentary peak voltage as indicated at 23 in FIG. 3, which voltage is substantially twice that of the voltage V1.

Simultaneously with the closing of the switch S and the momentary increased voltage peak at the point 21, the stored voltage source is applied across the striking circuit capacitor *Ct* resulting in the transient current in the primary of the transformer 15 providing an extremely high voltage on the secondary to strike the lamp 13. This portion of the operation is identical to that described in FIG. 1. An important feature of the invention, however, resides in the fact that the momentary increased voltage at the point 21 is automatically assured of occurring at the same point in time as the striking of the lamp 13 as a result of both the booster circuit portion and the striking circuit being responsive to the closing of the switch S.

With the high peak value of voltage as indicated at 23 in FIG. 3 appearing across the lamp 13 at the point in time of striking of the lamp, firing of the lamp is assured and the discharge of the high voltage is depicted between the lines T1 and T2 in FIG. 3. When the voltage V at the point 21 decreases sufficiently below the stored voltage on the capacitor C so that the diode D can now conduct, the power or energy stored on the storage capacitor C can all avalanche through the lamp 13 to provide the desired high intensity flash. In this respect, it should be noted that the diode D is in a sense functioning as a switch since it permits the boosted voltage to be retained at the point 21 at the time of its generation; that is, the capacitor *Cb* cannot discharge back through the diode and closed switch S because of the orientation of the diode. Thus it is assured that this momentary increased voltage is available across the lamp at the time of striking.

After the lamp is extinguished; that is, at the time T2 shown in FIG. 3, and when the switch S is open to its solid line position, the storage capacitor C will then again be charged as indicated by the curve 24 through the resistance R preparatory to a subsequent firing of the lamp. Also, the capacitor Cb will be charged through the diode D preparatory to providing the momentary increased voltage all as described when a subsequent firing is to take place.

The circuit of FIG. 4 operates in substantially the same manner as the circuit of FIG. 2 except that the boosted voltage is negative an applied to the lower

lamp terminal. Thus, referring to FIG. 4, with the switch S' open as shown, the lower side of the capacitor Cb' will charge up to the positive given voltage V1 through the resistance Rt. When the switch S' is closed to initiate action of the striking circuit, ground is immediately applied to the lower side of the capacitor Cb'. Since the voltage across the capacitor cannot change instantaneously, the other side of the capacitor connected to the terminal 21' of the lamp 13 immediately jumps to the value of −VI. Thus the total voltage across the lamp terminals at this instantaneous moment in time is effectively 2V1.

In the circuits of FIGS. 2 and 4, the term "voltage source" is used herein to designate generally the combination of the battery 10, charging resistance R, and storage capacitor C. The term "initiating means" is used to designate the switch S or S' since the closing of this switch initiates operation of the striking circuit and also of the booster means for providing the increased voltage. The term "striking means" is meant to cover the various elements enclosed within the dashed line 14.

From the foregoing description, it will be evident that the present invention has provided a very simple and economical means for vastly improving the reliability of stroboscopic lighting circuits. All of the advantages heretofore set forth with respect to providing an increased firing voltage at the time of striking of the lamp are thus realized.

What is claimed is:

1. In a gas discharge lamp firing circuit, the combination comprising: a voltage source; a storage capacitor connected across said voltage source; a gas discharge lamp; a striking means for said lamp; initiating means for operating said striking means; and booster means for raising the voltage across said lamp from said source means for firing said lamp, the boosted voltage for initiating firing of said lamp being available at the same point in time that said striking means is operated, said initiating means comprising a switch means connected between said voltage source and said striking means, and said booster means including a booster capacitor connected between said lamp and a junction point for receiving voltage from said storage capacitor when said switch means is closed; and a diode connected between the point of connection of said booster capacitor to said lamp and the junction of said switch means and said storage capacitor, said diode being oriented to permit charging of said booster capacitor by said voltage source when said switch means is open and to block current flow from said booster capacitor through said switch means when said switch means is closed.

2. A circuit for assuring firing of a stroboscopic gas discharge lamp comprising, in combination:

a. source means including a voltage source and a storage capacitor connected across said voltage source for providing a given voltage for firing said lamp;

b. striking means coupled to said lamp for effecting at least a partial ionization of gas in said lamp to ready said lamp for firing;

c. means for initiating operation of said striking means; and

d. voltage boosting means connected to said lamp and responsive to said means for initiating operation of said striking means to provide a substantially increased voltage to said lamp over said given voltage at the time of striking of said lamp, whereby firing of said lamp is assured, said means for initiating operation of said striking means including a normally open switch means connected between said source means and said striking means, said voltage boosting means including a booster capacitor connected between said lamp and the junction point of said switch means and said striking means; and a diode connected between the point of connection of said booster capacitor to said lamp and the junction point of said switch means and said storage capacitor, whereby said booster capacitor normally has a voltage on one side corresponding to said given voltage, closing of said switch means applying ground to said one side of said booster capacitor to thereby boost the voltage in a negative direction on the other side so that the voltage across said lamp is substantially double said given voltage, said diode being oriented to block current flow from said booster capacitor back through said switch means when closed so that the boosted voltage is available to initiate firing of said lamp.

3. A circuit for assuring firing of a stroboscopic gas discharge lamp comprising, in combination:

a. source means including a voltage source and a storage capacitor connected across said voltage source for providing a given voltage for firing said lamp;

b. striking means coupled to said lamp for effecting at least a partial ionization of gas in said lamp to ready said lamp for firing;

c. means for initiating operation of said striking means; and

d. voltage boosting means connected to said lamp and responsive to said means for initiating operation of said striking means to provide a substantially increased voltage to said lamp over said given voltage at the time of striking of said lamp, whereby firing of said lamp is assured, said means for initiating operation of said striking means including a normally open switch means connected between said source means and said striking means, said voltage boosting means including a booster capacitor connected between said lamp and the junction point of said switch means and said striking means; and a diode connected between the point of connection of said booster capacitor to said lamp and the junction point of said switch means and said storage capacitor, whereby said booster capacitor normally has a voltage on one side corresponding to said given voltage, closing of said switch means applying said given voltage to the other side of said booster capacitor to thereby boost the voltage on said one side to substantially double its value, said diode being oriented to block current flow from said booster capacitor back through said switch means when closed so that the boosted voltage is available to initiate firing of said lamp, said diode then passing energy from said source means to said

lamp when said boosted voltage drops below said value of said given voltage to thereby complete firing of said lamp.

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