

[54] **CIRCUIT ARRANGEMENT FOR THE IGNITION AND ALTERNATING CURRENT SUPPLY OF A GAS AND/OR VAPOR DISCHARGE LAMP**

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 [51] Int. Cl.H05b 37/00
 [58] Field of Search.....315/100 U, 243, 362, 258, 283, 315/289, 205

[56] **References Cited**

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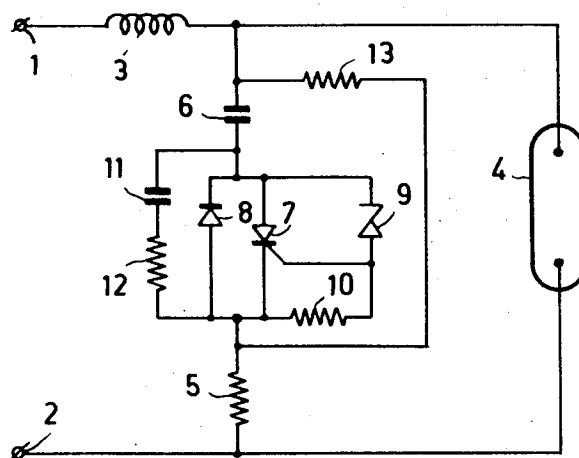
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[57] **ABSTRACT**

An ignition circuit for a discharge lamp comprising a ballast impedance in series with the lamp across the AC supply terminals. A capacitor and an SCR connected in series across the lamp electrodes. A diode connected anti-parallel to the SCR. A zener diode between the SCR anode and gate electrodes. The series circuit, including the ballast impedance, the capacitor, and the SCR and diode connected in anti-parallel, is under critically damped.

12 Claims, 3 Drawing Figures



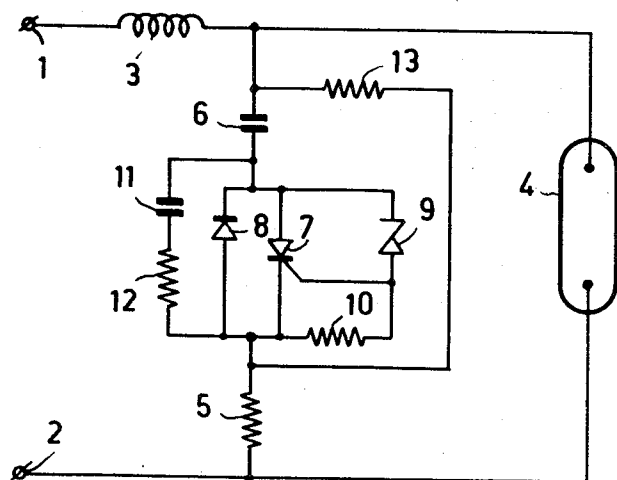


fig. 1

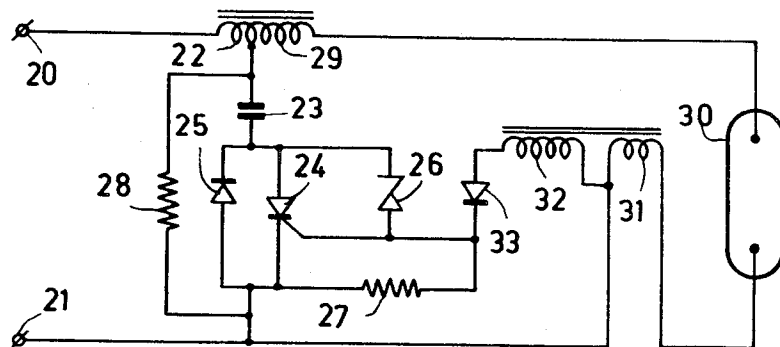


fig. 2

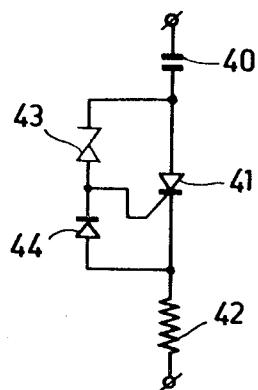


fig. 3

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CIRCUIT ARRANGEMENT FOR THE IGNITION AND ALTERNATING CURRENT SUPPLY OF A GAS AND/OR VAPOR DISCHARGE LAMP

This invention relates to a circuit arrangement for the ignition and alternating current supply of a gas and/or vapor discharge lamp wherein a ballast impedance, comprising an inductance is present which in the switched-on condition of the lamp is connected in a first series arrangement with said lamp to the input terminals for the supply of the lamp and in which a part of this first series arrangement that includes the lamp is shunted by a second series arrangement which includes at least a capacitor and a controlled semiconductor rectifier.

Such a circuit arrangement is known, for example, from Swiss Patent specification 455,937. A drawback of this known circuit arrangement is that the capacitor does not carry any voltage when the controlled semiconductor rectifier becomes conducting for the first time. The current flowing through the controlled semiconductor rectifier and hence the voltage peak to be generated for the discharge lamp to be ignited will therefore have a fairly low value. A further drawback is that when the discharge lamp is not ignited after the first starting attempt, the capacitor receives a bias voltage of a polarity such that the subsequent current peaks through the controlled semiconductor rectifier will still be smaller than the first current peak. In addition the auxiliary circuits of the known arrangement mentioned above are fairly complicated.

It is an object of the present invention to eliminate or at least to mitigate these drawbacks.

An arrangement according to the invention for the ignition and alternating current supply of a gas and/or vapor discharge lamp, wherein a ballast impedance comprising an inductance is present which in the switched-on condition of the lamp is connected in a first series arrangement with said lamp, said first series arrangement being connected to input terminals for the supply of the lamp and in which a part of this first series arrangement comprising the lamp is shunted by a second series arrangement which includes at least a capacitor and a controlled semiconductor rectifier, is characterized in that the controlled semiconductor rectifier is shunted by a branch which includes an uncontrolled rectifier connected anti-parallel to the controlled semiconductor rectifier. An electric circuit element is provided between the anode and the control electrode of the controlled semiconductor rectifier such that when a threshold voltage between its anode and cathode is exceeded, the connection of the input terminals including the second series arrangement and the uncontrolled rectifier being less than critically damped.

In the respect a critically damped connection or circuit is understood to mean a connection or circuit wherein the current initially increases when switched across a direct current source, subsequently decreases and then becomes zero and starts to flow again in the same direction.

In a connection or circuit which is less than critically damped the current will attempt to reverse its flow direction after it has become zero.

An advantage of an arrangement according to the invention is that the capacitor is first charged to approximately the peak value of the line supply voltage before the controlled semiconductor rectifier becomes conducting in the next half period of the alternating supply voltage. This implies that comparatively high voltage peaks are available for the ignition of the lamp. A further advantage of a circuit arrangement according to the invention is that subsequent voltage peaks will have at least the same intensity even when the lamp is not yet ignited after the first starting attempt.

The invention is based on the novel concept that the capacitor of the second series arrangement is first charged through the uncontrolled rectifier. When subsequently the voltage at the input terminals of the arrangement has changed its polarity, the capacitor will at first not be discharged because the controlled semiconductor rectifier is still cut off and in addition because the lamp is not yet ignited. Only when the instan-

taneous value of the voltage between the supply terminals has reached a given limit value will the semiconductor rectifier be rendered conducting through the electric circuit element between said main electrode (anode) and the control electrode of the controlled semiconductor rectifier. The voltage on the capacitor, which is approximately equal to the peak value of the alternating supply voltage, will then decrease to zero and will subsequently be charged to a negative value. Then the current flowing through the controlled semiconductor rectifier will become zero so that this rectifier returns to the non-conducting condition again. Subsequently a current will flow again, namely in the reverse direction through the uncontrolled rectifier, which charges the capacitor. The process described may occur one or more times for each (odd) half period of the supply voltage, namely as a function of the damping and of the threshold voltage of the electric circuit element between the said main electrode and the control electrode of the controlled semiconductor rectifier. The oscillations of the voltage on the capacitor and hence the oscillations of the voltage on the second series arrangement are rather powerful because the controlled semiconductor rectifier becomes conducting only at an instant when the supply voltage has reversed its polarity.

When the lamp is ignited it is fed by the alternating voltage source through the ballast impedance.

Although it is known to use a series arrangement of a capacitor and a controlled semiconductor rectifier for generating voltage peaks, whereby this rectifier is shunted by an uncontrolled rectifier connected anti-parallel thereto, in this known case no further voltage to maintain the discharge which has just been initiated after generating a voltage peak is available. Such a known arrangement is described, for example, in U.S. Pat. No. 3,349,284. In the arrangement described in said Patent the object is not the ignition of a discharge lamp, but rather the generation of an ignition spark for an engine wherein the maintenance of a discharge is not necessary.

The electric circuit element between the control electrode and the anode of the controlled semiconductor rectifier may be, for example, a resistor.

A circuit arrangement according to the invention preferably includes a zener diode between the control electrode and the anode of the controlled semiconductor rectifier, the pass direction of the zener diode being opposite to the pass direction of the controlled semiconductor rectifier.

An advantage of this solution is that the voltage at which the controlled semiconductor rectifier becomes conducting is exactly fixed, namely by the cut-off voltage of the zener diode. The voltage peaks will therefore always have approximately the same value.

It is possible for the second series arrangement to shunt only the discharge lamp. It is likewise feasible that the second series arrangement forms a shunt across the discharge lamp and a part of the ballast impedance.

In the last-mentioned case the circuit arrangement is preferably formed in such a manner that a primary winding of a transformer is provided in series with the lamp and the ballast impedance, a terminal of a secondary winding of said transformer being connected to the control electrode of the controlled semiconductor rectifier and another terminal of this secondary winding being connected to the cathode of the controlled rectifier such that the controlled semiconductor rectifier becomes conducting when a current flows in at least one direction through the primary winding of the transformer.

An advantage of this embodiment is that after the ignition of the lamp, the controlled semiconductor rectifier can be maintained continuously conducting so that no unnecessary pulses are applied to the lamp. The following is to be noted for the purpose of explanation. In general the operating voltage in a discharge lamp will be lower than its ignition voltage. In many cases an ignition device for a discharge lamp will therefore be proportioned such that this ignition device is active at a voltage which is equal to or larger than the ignition voltage of the lamp, but which is not active at a voltage which is equal to the

operating voltage of the lamp. However, if as described above the second series arrangement forms a shunt across the lamp together with a part of the ballast impedance, the decrease of the voltage across the lamp electrodes after the ignition of the lamp can less satisfactorily be utilized for switching off the ignition device. In the last-mentioned preferred embodiment of a circuit arrangement according to the invention the controlled semiconductor element can now be successfully maintained permanently conducting in the ignition portion, namely without introducing asymmetry, because the controlled semiconductor rectifier always has an uncontrolled rectifier connected anti-parallel thereto.

In an advantageous embodiment of the last-mentioned preferred circuit arrangement a further rectifier is provided in at least one of the connections from the secondary winding of the transformer to the control electrode.

An advantage of this last-mentioned embodiment is that voltages of incorrect polarity can not be applied to the control electrode of the controlled rectifier.

It is feasible that the previously mentioned zener diode and the uncontrolled rectifier, connected anti-parallel to the controlled semiconductor rectifier, are parallel-arranged.

Preferably the uncontrolled rectifier is series-arranged with the zener diode. This leads to a very simple ignition circuit.

In order that the invention may be readily carried into effect, a few embodiments thereof will now be described in detail, by way of example, with reference to the accompanying diagrammatic drawing in which:

FIG. 1 shows a circuit arrangement according to the invention;

FIG. 2 shows a further circuit arrangement according to the invention; and

FIG. 3 shows a further embodiment of a shunt circuit of at least one discharge lamp in a circuit arrangement according to the invention.

In FIG. 1 the reference numerals 1 and 2 denote input terminals which are intended to be connected to an alternating voltage source of, for example, 220 volts, 50 Hz. The terminal 1 is connected to an inductor 3. The other side of this inductor 3 is connected to an electrode of a discharge lamp 4. This is a high-pressure mercury vapor discharge lamp provided with metal halogenides. The other electrode of the lamp 4 establishes contact through a connection wire with the terminal 2. The discharge lamp 4 is shunted by a circuit comprising a series arrangement of a resistor 5 and a remaining circuit portion. This remaining portion consists of a capacitor 6 which is connected to the wire from the inductor 3 to the lamp 4. The other end of the capacitor 6 is connected to a parallel arrangement of a controlled semiconductor rectifier (thyristor) 7 and a diode 8 connected anti-parallel thereto. The said resistor 5 is also arranged in series with the rectifiers 7 and 8. A zener diode 9 is arranged between the collector (anode) of the thyristor 7 and the control electrode thereof. Furthermore a resistor 10 is provided between the control electrode of the thyristor 7 and its emitter (cathode). The diode 8 is furthermore shunted by a series arrangement of a capacitor 11 and a resistor 12. Together with the parallel branches including the rectifiers 7 and 8, the capacitor 6 is shunted by a resistor 13. The circuit 1, 3, 6, 7/8, 5, 2 is less greatly damped than a critically damped circuit.

The operation of the circuit described is as follows (in the first instance the influence of the circuit elements 10 to 13 inclusive are left out of consideration). When the terminals 1 and 2 are connected to the alternating voltage source, the capacitor 6 will be charged, namely through the resistor 5 and the diode 8 during the next half period when the terminal 2 is positive relative to the terminal 1. During the next half period when the terminal 1 is positive relative to the terminal 2, the capacitor 6 will not yet be discharged in the first instance. This happens only when the instantaneous value of the supply voltage has become so high that together with the voltage across the capacitor the threshold voltage of the zener diode 9 is reached. Then the thyristor 7 will be triggered. The capacitor

6 will then be discharged and subsequently be charged to a negative value. Subsequently the thyristor 7 (due to its current becoming zero) will become non-conducting and the capacitor 6 will be recharged through the diode 8. This process may be repeated one or more times during the same half period. This is dependent inter alia on the choice of the cut-off voltage of the zener diode 9 and the magnitude of other circuit elements such as the resistor 5. The capacitor charges and discharges indicated in this manner cause high voltage peaks across the series arrangement 5, 7/8, 6 which peaks are applied across the electrodes of the discharge lamp 4. Subsequently the lamp 4 ignites. If this lamp is not ignited immediately, one or more voltage peaks are again generated during the second half period thereafter. When the lamp 4 is ignited as a result of the generated voltage peaks, the discharge is maintained by the supply voltage present. After the ignition of the lamp 4 the voltage across the bridge 6, 7, 8, 5 drops down to the operating voltage of the lamp. The zener diode 9 is now proportioned in such a manner that the control electrode of the thyristor 7 does not receive control pulses at this low operating voltage. The impedance 3 stabilizes the discharge in the lamp 4. The resistor 5 limits the current through the thyristor 7 during the ignition process. The resistor 10 has the task of preventing the thyristor 7 from becoming conducting as a result of voltage pulses during the operating condition of the lamp 4. The series arrangement of the capacitor 11 and the resistor 12 also serves to maintain the thyristor 7 non-conducting upon the occurrence of short voltage transients during the operating condition of the lamp 4. The resistor 13 serves to discharge the capacitors 6 and 11 if the starter (5 to 13 inclusive) is removed from the holders.

In a certain embodiment the lamp 4 was a high-pressure mercury vapor discharge lamp of 400 watts. The ignition voltage of this lamp was approximately 600 volts and the operating voltage was approximately 135 volts. The inductor 3 had a value of approximately 0.14 henry. The resistor 5 had a value of approximately 15 ohms, the resistor 10 had a value of 680 ohms, the resistor 12: 4.7 kohms, the resistor 13: 10 Mohms. The capacitor 6: 0.47 μ F, the capacitor 11: 0.01 μ F, the breakdown voltage of the zener diode 9 was approximately 500 volts. In this embodiment voltage peaks were obtained having peak values of approximately 660 volts across the electrodes of the lamp 4, whereupon this lamp was ignited.

In FIG. 2 the reference numerals 20 and 21 denote connecting terminals intended to be connected to a voltage source of 220 volts, 50 Herz. A connection wire leads from the terminal 20 to the primary winding of a ballast impedance formed as an autotransformer. This primary winding has the reference numeral 22. The other end of this primary winding is connected to a capacitor 23. In a corresponding manner to that of capacitor 6 of FIG. 1, the capacitor 23 is connected to a thyristor 24 to which a diode 25 is anti-parallel connected. The emitter (cathode) of the thyristor 24 is connected to the supply terminal 21. A zener diode 26 is provided between the anode and the control electrode of the thyristor 24. A resistor 27 is provided between the control electrode and the emitter (cathode) of the thyristor 24. The series arrangement of capacitor 23 and thyristor 24 is shunted by a resistor 28. The secondary winding of the transformer, the winding 22 of which forms the primary, is denoted by the reference numeral 29. The winding 29 is connected to one electrode of a high-pressure sodium vapor discharge lamp 30. The other electrode of the lamp 30 is connected to supply terminal 21 through the primary winding 31 of a transformer. The secondary winding 32 of the transformer whose winding 31 forms the primary is connected through a diode 33 to the control electrode of the thyristor 24.

The operation of this circuit is largely identical to that of FIG. 1. In the case of FIG. 2 the high voltage peaks generated in the bridge (23, 24) are still further amplified by the transformer action of the windings 22 and 29 of the transformer. A further difference from the circuit of FIG. 1 is that when the lamp 30 is ignited a current flows through the primary winding

31 so that a voltage is induced in the winding 32 which produces, through the diode 33, a voltage on the control electrode of the thyristor 24 (relative to the cathode of this thyristor 24) which voltage maintains this thyristor 24 conducting. The resistors 27 and 28 again serve for the purpose of safety.

In one particular embodiment the transformation ratio of the transformer 22, 29 was 1 to 7.5. The lamp 30 was a high-pressure sodium vapor discharge lamp of approximately 400 watts; its ignition voltage was approximately 3,000 volts and its operating voltage was approximately 115 volts. The resistor 27 had a value of 680 ohms and the resistor 28 had a value of 10 Mohms. The capacitor 23 had a value of 0.47 μ F. The cut-off voltage of zener diode 26 was approximately 500 volts and the transformation ratio of the transformer 31, 32 was 1 to 100.

In the case of FIG. 2 just described, voltage peaks having a peak value of approximately 4,000 volts were generated across the lamp 30 by the ignition device during the start. Thereupon this lamp was ignited.

FIG. 3 finally shows a further embodiment of a shunt by which a discharge lamp can be shunted. This shunt is used, for example, in place of the circuit portion which is denoted by the reference numerals 5 to 13 inclusive in FIG. 1. In FIG. 3 the reference numeral 40 denotes a capacitor which is arranged in series with a thyristor 41 and a resistor 42. A zener diode 43 is arranged between the collector (anode) of the thyristor 41 and its control electrode. A diode 44 is arranged between the control electrode of the thyristor 41 and emitter (cathode). The diodes 43 and 44 are in this case connected together in series. In the case of FIG. 3 the diode 44 is therefore also provided in a branch which shunts the thyristor 41, the diode 44 and the thyristor 41 being connected anti-parallel to each other. In this case the capacitor 40 is charged through the diode 44 and the zener diode 43. This capacitor is discharged across the thyristor 41 (which occurs only when the cut-off voltage across the zener-diode 43 has been reached) in substantially the same manner as is indicated in FIG. 1 for the capacitor 6, the thyristor 7 and the zener diode 9.

The described circuit arrangements according to the invention includes only one controlled semiconductor element. The control circuit of this element is formed in a very simple manner.

What Is Claimed Is:

1. A circuit arrangement for the ignition of and supply of alternating current to a gas discharge lamp comprising, a pair of input terminals adapted to be connected to a source of AC supply current, a ballast impedance including an inductance connected in a first series arrangement with said lamp to the input terminals, a capacitor, a controlled semiconductor rectifier, means for shunting a part of said first series arrangement comprising the lamp with a second series arrangement which at least includes said capacitor and said controlled semiconductor rectifier, said controlled semiconductor rectifier being shunted by a branch circuit which includes an uncontrolled rectifier connected parallel to the controlled semiconductor rectifier but oppositely polarized, an electric voltage breakdown circuit element connected between the anode and the control electrode of the controlled semiconductor rectifier so that the controlled semiconductor rectifier becomes conducting when a given threshold voltage appears between its anode and cathode, and wherein the circuit including the input terminals, the second series arrangement and the uncontrolled rectifier is less than critically damped.

2. A circuit arrangement as claimed in claim 1, wherein the voltage breakdown element comprises a zener diode connected with its pass direction opposite to the pass direction of the controlled semiconductor rectifier.

3. A circuit arrangement as claimed in claim 1 wherein the second series arrangement shunts the lamp and a part of the ballast impedance, said arrangement further comprising a transformer with a primary winding in series with the lamp and

the ballast impedance, means connecting a secondary winding of said transformer to the control electrode of the controlled semiconductor rectifier and to the cathode of the controlled rectifier such that the controlled semiconductor rectifier becomes conducting when a current flows at least in one direction through the primary winding of the transformer.

4. A circuit arrangement as claimed in claim 3, wherein said means connecting the secondary winding of the transformer to the control electrode includes a rectifier.

5. A circuit arrangement as claimed in claim 2, further comprising means connecting the uncontrolled rectifier and the zener diode in series with each other in said branch circuit.

6. A starter particularly suitable for a circuit arrangement as claimed in claim 1 provided with a capacitor in series with a controlled semiconductor rectifier, characterized in that the controlled semiconductor rectifier is shunted by a branch including an uncontrolled rectifier which is connected anti-parallel to the controlled semiconductor rectifier, an electric circuit element being provided between the anode and the control electrode of the controlled semiconductor rectifier such that the controlled semiconductor rectifier becomes conducting when a threshold voltage between its anode and cathode is exceeded.

7. An ignition circuit for a discharge lamp comprising, input terminals for connection to a source of alternating current, a ballast impedance including an inductance connected in series with said lamp across said terminals, a capacitor and a semiconductor controlled rectifier connected in series, means connecting the series arrangement of the capacitor and controlled rectifier in shunt with the lamp, a rectifier element connected parallel to the semiconductor controlled rectifier and with reverse polarity, an electric circuit element having a given breakdown voltage connected between the anode and the control electrode of the semiconductor controlled rectifier so that the controlled rectifier is triggered into conduction when the voltage between its anode and cathode exceeds a predetermined threshold level, the circuit including at least a part of the ballast impedance, the capacitor, the semiconductor controlled rectifier and said rectifier element being less than critically damped.

8. A circuit as claimed in claim 7 wherein the electric circuit element between the control electrode and the anode of the semiconductor controlled rectifier comprises a zener diode connected with a polarity which is opposite to that of the controlled rectifier.

9. A circuit as claimed in claim 7 wherein said series arrangement shunts the lamp and a part of the ballast impedance, a transformer, means connecting a primary winding of the transformer in series with the lamp and the ballast impedance, means connecting one terminal of a secondary winding of said transformer to the control electrode of the controlled rectifier and another terminal of said secondary winding to the cathode of the controlled rectifier so that the controlled rectifier begins to conduct when a current flows at least in one direction through the primary winding of the transformer.

10. A circuit as claimed in claim 9 further comprising a second rectifier connected between said control electrode and said one terminal of the transformer secondary winding.

11. A circuit as claimed in claim 7 further comprising means connecting said breakdown element in series with said rectifier element and with the rectifier element connected between the cathode and the control electrode of the semiconductor controlled rectifier.

12. A circuit as claimed in claim 7 wherein the amplitude of the AC supply voltage to which said input terminals are to be connected is lower than the ignition voltage of the discharge lamp, said capacitor and rectifier element being operative together with the supply voltage at said input terminals to develop a voltage across the lamp terminals that is greater than the lamp ignition voltage during given half cycles of the AC supply voltage.

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