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van der Meulen

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[54] **APPARATUS FOR AUTOMATICALLY ADJUSTING THE OPERATION TIME OF AN IRRADIATION DEVICE**

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[58] **Field of Search** 315/56, 58, 59, 60, 72, 315/101, 104, 105, 106, 241, 245; 250/409, 411, 421

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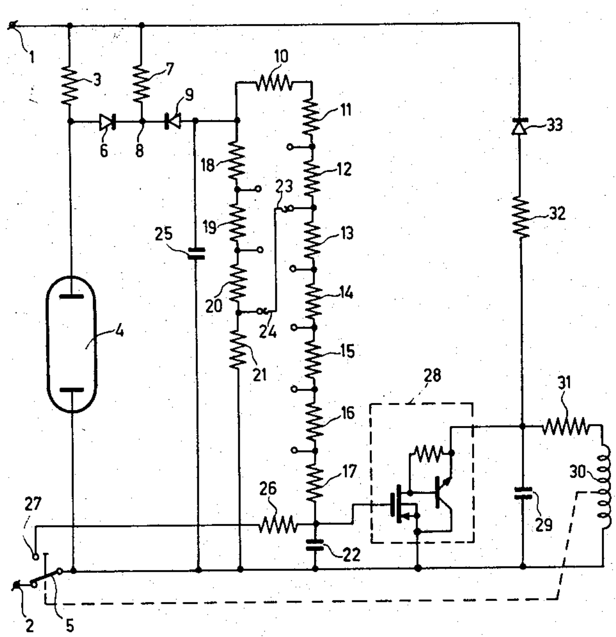
[57] **ABSTRACT**

The invention relates to a sunlamp device.

According to the invention a timing circuit of the sunlamp device is first fed through a voltage which is equal to the voltage across the discharge tube and in a subsequent stage by a voltage which is proportional to the mains voltage. It is achieved thereby that a sunlamp is obtained which immediately after ignition of the discharge tube can be used for irradiation, and in which individual differences in the voltage-increasing rate of the operating voltage of the discharge tube and possible mains voltage deviations are compensated for so that the irradiation quantity is maintained equal as well as possible to the desired quantity.

14 Claims, 2 Drawing Figures



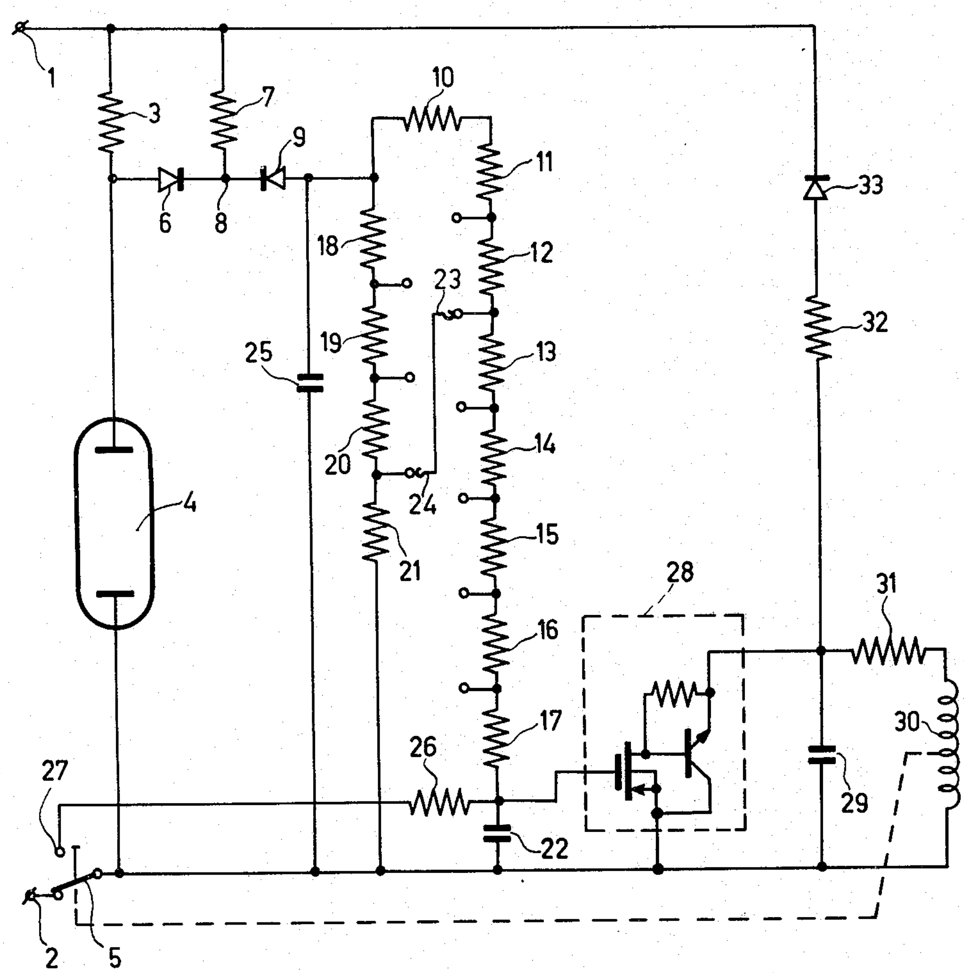

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Fig.1

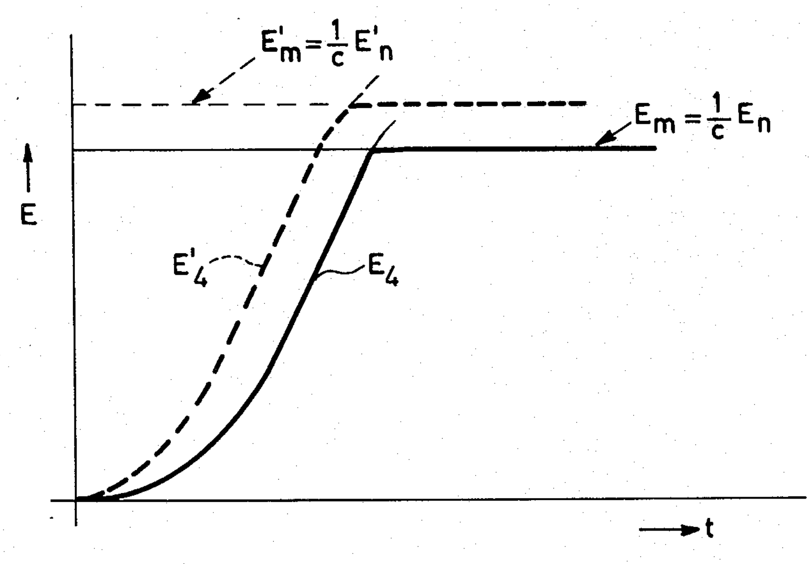

Fig.2

APPARATUS FOR AUTOMATICALLY ADJUSTING THE OPERATION TIME OF AN IRRADIATION DEVICE

The invention relates to an irradiation device provided with a gas and/or vapour discharge tube whose operating voltage increases after ignition, which discharge tube is in series with at least a stabilising resistor across two input terminals of the device, the stabilising resistor being shunted by an auxiliary branch having a tap. A timing circuit is provided for automatic termination of the irradiation and having a branch connected in parallel with the discharge tube through the tap.

A known irradiation device of the kind mentioned above is described, for example, in Netherlands Pat. application No. 6901328 in which a sunlamp is concerned.

A drawback of the known irradiation device is that irradiation cannot start until after the device is switched on and the discharge tube is heated sufficiently. A further drawback is that if during irradiation the value of the supply voltage deviates from the nominal supply value, an irradiated person receives an incorrect quantity of irradiation so that the irradiation either has little effect or results in an excessive discolouration of the skin (too much tan).

It is known to start irradiation right after ignition of a discharge tube so that the heating time of the discharge tube during which the operating voltage of the discharge tube increases to a final value also forms part of the total irradiation period.

In the latter known case there is, however, the drawback that the discharge tube of one device reaches its operating condition (i.e., the final value of the operating voltage) faster than another device, namely due to individual differences between discharge tubes of one and the same type. In addition the value of the supply voltage during irradiation also has an influence on the heating period and on the operating condition of the discharge tube. Also in this case the irradiation quantity may deviate from the desired quantity, this time due to both supply voltage deviations and to individual differences between discharge tubes of one and the same type.

It is an object of the invention to provide an irradiation device of the kind described in the preamble in which irradiation starts right after ignition of the discharge tube and in which individual differences in the heating period of the discharge tubes and also supply voltage variations have at most only a slight influence on the irradiation quantity. According to the invention this is realised by automatically modifying the duration of irradiation.

According to the invention an irradiation device is provided with a gas and/or vapor discharge tube whose operating voltage increases after ignition. The discharge tube is in series with at least a stabilising resistor across two input terminals of the device and the stabilising resistor is shunted by an auxiliary branch having a tap. A timing circuit is provided for automatic termination of the irradiation in which at least a branch of the timing circuit is connected in parallel with the discharge tube through the tap. The invention is characterized in that the part of the auxiliary branch located between the discharge tube and the tap incorporates a first diode and that the part of the auxiliary branch located on the other side of the tap incorporates a first non-capacitive impedance, said branch of the timing circuit comprising at least a second similar non-capacitive impedance, while an integrating member associated with the timing circuit is arranged across at least part of the second impedance. By means of said member a command for termination of the irradiation is given. Means are provided by which the current through the first impedance of the auxiliary branch can only flow in a direction corresponding to the pass direction of the first diode.

An advantage of an irradiation device according to the invention is that not only is the heating time of the discharge tube used for supplying the irradiation quantity, but also variations in the heating time of the discharge tubes and supply voltage deviations are compensated for.

As already noted the said disturbing influences are compensated for by automatic modification of the irradiation time. The irradiation quantity obtained then does not substantially deviate from the desired irradiation quantity.

The invention is based on the recognition of the fact to feed the timing circuit with a variable voltage which at the commencement of irradiation (hence when the discharge tube is heated) is substantially directly proportional to the instantaneous operating voltage of the discharge tube and in which the second part of the irradiation (when the discharge tube is heated up sufficiently) is substantially directly proportional to the effective value of the supply voltage then present.

This split-up into two parts of the voltage feeding the timing circuit is realised with the aid of the diode in the auxiliary branch shunting the stabilising resistor. In fact, when during the increase of the operating voltage of the discharge tube the voltage across the stabilising resistor is of course still fairly high, the latter voltage exceeds the value $(Z_1/Z_1 + Z_2) \times E_n$ in which Z_1 is the value of the first impedance in the auxiliary branch and Z_2 is the value of the second impedance in the timing circuit. Z_1 and Z_2 actually constitute a potential divider between whose ends the supply voltage (E_n) is present. At this time the first diode is conductive because the voltage drop across the stabilizing resistor exceeds the voltage drop across the first impedance thereby effectively clamping the tap to the operating voltage of the discharge tube.

At the commencement of irradiation a current will flow through the first diode until the discharge tube has such a high operating voltage that the voltage across the stabilising resistor drops below the value $(Z_1/Z_1 + Z_2) \times E_n$. Then the current through the first diode stops whereby the timing circuit is no longer influenced by the discharged tube operating voltage.

All this means that a voltage is present across the second impedance of the timing circuit at the commencement of irradiation, which voltage is equally large as — and then also increases equally with — the operating voltage of the discharge tube, while later on — during the second part of the irradiation — a voltage $(Z_2/Z_1 + Z_2) \times E_n$ is present across the second impedance of the timing circuit, which voltage is of course determined by the supply voltage and not any longer by the voltage across the discharge tube.

In view of the foregoing it is apparent that the integrating member of the timing circuit gives an earlier termination command when the discharge tube is heated at a faster rate and/or when the supply voltage has a higher value. This then leads to a shorter irradiation duration and hence to the desired irradiation quantity.

The step to ensure that the current through the first impedance in the auxiliary branch can only flow in a direction corresponding to the pass direction of the first diode may be taken for example by designing the device according to the invention for connection to a direct voltage supply and this with a correct polarity of the terminals.

In a preferred embodiment of an irradiation device according to the invention intended for connection to an alternating voltage supply, the means by which the current through the first impedance in the auxiliary branch can only flow in a direction corresponding to the pass direction of the first diode consists of a second diode arranged between the second impedance and the tap, the pass directions of the two diodes being directed either towards the tap or away from the tap.

An advantage of this embodiment is that the device can also be operated on an alternating voltage supply without this having a disturbing influence on the integrating member of the timing circuit.

The first impedance and the second impedance of a device according to the invention may be formed as inductors.

In a further preferred embodiment of an irradiation device according to the invention the first impedance and the second impedance are formed as resistors.

An advantage of this preferred embodiment is that it is relatively cheap.

The integrating member of the irradiation device may consist of, for example, a motor which opens a contact when it has made a number of revolutions so that a main contact in the current circuit through the discharge tube is likewise opened. This leads to a termination of the irradiation.

In a further preferred embodiment of an irradiation device according to the invention the integrating member consists of a series arrangement of a first capacitor and a first variable resistor in which the capacitor is coupled to an auxiliary device associated with the timing circuit and in which the irradiation is automatically terminated in that a switch in the series arrangement of at least the discharge tube and the stabilising resistor is opened through the auxiliary device when a given threshold voltage of the first capacitor is reached.

An advantage of this preferred embodiment is that no moving parts need be present in the control members. A further advantage of this device is that a different irradiation time can be adjusted in a simple manner by variation of the value of the variable resistor.

In a further preferred embodiment of an irradiation device according to the invention the first variable resistor is formed as a first potentiometer and the second impedance is formed as a second potentiometer in which the wipers on the two potentiometers are electrically interconnected.

An advantage of the latter embodiment is that the irradiation time increasing from day to day can be adjusted with one, the so-called first, potentiometer while a correction adapted to the sensitivity of the skin of the person to be irradiated can be realized with the second potentiometer.

The auxiliary device which is coupled to the first capacitor may be formed in various ways, for example, it may be provided with a breakdown diode.

In a further advantageous embodiment of a device according to the invention the auxiliary device consists of a parallel arrangement of a second capacitor, a branch comprising an energising winding of a relay and an output switching circuit of an amplifier device. This parallel arrangement is connected in series with a first current-limiting member and a third diode across the input terminals of the device. The contact of the relay is constituted by the switch in series with the discharge tube.

An advantage of this preferred embodiment is that a simple but very reliable auxiliary apparatus for termination of the irradiation may be achieved.

Prior to the commencement of a subsequent irradiation the first capacitor of the timing circuit must be discharged again. This may be effected, for example, by a separate switch which is arranged through a resistor across the capacitor and in which closing of said switch causes this capacitor to discharge. Subsequently this switch must be opened again.

In a further preferred embodiment of an irradiation device according to the invention a circuit is closed in a position of the main switch in the series connection of the discharge tube and the stabilising resistor, in which position the said series connection is interrupted, and this circuit is constituted by the first capacitor, the said switch and a second current-limiting member.

An advantage of the latter preferred embodiment is that when the main switch is opened the capacitor across the second current-limiting element is immediately discharged so that soon thereafter a subsequent person can be irradiated.

The invention will be further described with reference to the accompanying drawing in which:

FIG. 1 shows an electrical circuit diagram of a device according to the invention, and

FIG. 2 shows a graph indicating inter alia the voltage across the timing circuit of the device of FIG. 1 plotted against time.

In FIG. 1, input terminals 1 and 2 of the device according to the invention are intended to be connected to an alternating voltage supply of approximately 220 V, 50 Hz. The terminals 1 and 2 are connected by a series arrangement consisting of a stabilizing resistor 3, a discharge tube 4 which is capable of emitting ultraviolet radiation (a sunlamp) and a main switch 5. A connection point between the stabilising resistor 3 and the discharge tube 4 is connected through a first diode 6 to a resistor 7. The series arrangement of the diode 6 and the resistor 7 constitutes a shunt for the stabilising resistor 3. A diode 9 is also connected to a tap 8 located between the diode 6 and the resistor 7. The pass directions of the two diodes 6 and 9 face the tap 8. Two potentiometers are connected to the anode side of the diode 9. The first potentiometer includes the resistors 10 to 17 The potentiometer connected in parallel therewith includes the resistors 18 to 21. A first capacitor 22 is also included in series with the resistors 10 to 17. The capacitor 22 and the resistor 21 are connected to a connection leading to the supply terminal 2. A wiper 23 on the first potentiometer is electrically interconnected to a second wiper 24 of the second potentiometer. The second potentiometer is also shunted by a subsequent capacitor denoted by the reference numeral 25. A connection point between the resistor 17 and the capacitor 22 is connected through an auxiliary resistor 26 to a further contact 27 of the switch 5. Likewise a connection point between the resistor **17** of the first potentiometer and the capacitor **22** is connected to an amplifier device denoted by the reference numeral **28.** It is an amplifier provided with a MOS transistor. This amplifier **28** forms part of an auxiliary device also including a capacitor **29** and an energising winding **30** of a relay. The contact operated by the relay **30** is the switch **5.** An output switching circuit of the amplifier device **28** is connected in parallel with the capacitor **29** and with a series arrangement of the winding **30** and a further resistor **31.** This parallel arrangement is connected in series with a resistor **32** and a diode **33** between the terminals **2** and **1** of the device.

The operation of this device is as follows: The wiper **24** on the second potentiometer is firstly adjusted to a position which corresponds to the sensitivity of the skin of the person to be irradiated. This wiper is placed in the vicinity of the resistor **18** when the person's skin is very sensitive to irradiation and in the vicinity of the resistor **21** when the skin is very insensitive. On the first day of irradiation the wiper **23** on the first potentiometer is placed near the resistor **17.** In this situation the switch **5** is manually brought to the position at which the main current circuit is closed by the discharge tube **4.** Subsequently this discharge tube **4** is ignited and conveys current through the stabilising resistor **3** and on the other hand a current starts to flow through the winding **30** and the resistors **31, 32** and the diode **33** so that the switch **5** is maintained in the position then occupied. This is the instant of commencement of irradiation of the person. In this situation the discharge tube is first heated so that its operating voltage becomes higher and higher. The person to be irradiated then already receives ultraviolet radiation. In the situation then considered, the voltage across the stabilising resistor **3** is relatively high and is higher than is determined by the product of the supply voltage and the ratio of the resistor **7** relative to the resistor **7** added to the resistance of the complete second potentiometer. This means that a current starts to flow through the diode **6** during alternate half cycles of the alternating supply voltage when the terminal **2** is positive relative to terminal **1.** The capacitor **22** then starts to charge to the relatively low voltage between the points **2** and **8.** The rate of charging is of course also determined by the resistors of the two potentiometers connected in series with this capacitor. After the discharge tube **4** has operated for some time its operating voltage increases so that at a given instant the voltage across the resistor **7** is only determined mainly by the voltage division across the second potentiometer. Then the current through the diode **6** stops and the voltage between the points **8** and **2** becomes a substantially constant fraction of the supply voltage. The capacitor **22** is then charged with the aid of this further voltage **8, 2.** When at a given instant the negative threshold voltage of the amplifier device **28** is reached, the transistor in this device becomes conducting so that the relay winding **30** is short-circuited and thus can no longer retain the contact **5** in the given position. This contact is then opened and occupies the position at which the connection with contact **27** is established. This means on the one hand that the discharge tube is extinguished and on the other hand that the capacitor **22** is discharged again through the circuit **22, 26, 27, 5.** When the same person wants to be irradiated the next day again for which, as is known, a large irradiation quantity is generally to be used, he adjusts the wiper on the first potentiometer, i.e., the wiper **23,** to a higher position, hence in the direction of the resistor **11** so that he will receive a larger irradiation quantity. When a subsequent person whose skin sensitivity is different uses the irradiation device the wiper on the second potentiometer, i.e., the wiper **24,** will have to be adjusted to a different position so that the second person receives the correct irradiation quantity for his skin.

If for some reason or other the discharge tube **4** would relatively quickly reach its operating condition, the voltage between the points **2** and **8** would only be proportionally determined for a short time by the discharge tube and then be taken over by the supply voltage. This means that the capacitor **22** is then already soon fed through a relatively high voltage so that this capacitor reaches the threshold voltage at an earlier point of time and hence will sooner give a command to switch off the switch **5.** This is correct because a discharge tube which is rapidly heated means that the irradiation duration must be short to maintain a constant irradiation quantity. Also a high supply voltage leads to a short irradiation time because a high supply voltage also means that the voltage between the points **2** and **8** is relatively high.

Conversely a slightly longer irradiation time is obtained for a slowly heating discharge tube **4** and for relatively low supply voltages with a device as described in FIG. **1** so that the irradiation quantity remains substantially constant assuming that the situations are considered for fixed positions of the wipers **23** and **24.**

FIG. **2** is a graphic representation. The voltage inter alia between the points **8** and **2** of the device of FIG. **1** is plotted on the vertical axis in the graph, the solid line representing this voltage as a function of time. Initially, that is to say, shortly after ignition of the discharge tube the voltage between the points **2** and **8** is of course equal to the voltage E_4 across the discharge tube until the voltage across the discharge tube has reached a value $E_m = 1/c.\ E_n$ which is equal to fraction of the supply voltage E_n. This fraction, as already described hereinbefore, is determined by the potential divider of the resistor **7** and of the second potentiometer. The situation of the combination of a quickly heating discharge tube and a high supply voltage is respresented by a broken line in FIG. **2.** This case is denoted in FIG. **2** with indices. It can be seen that the voltage across the points **2** and **8** has become much higher within a short time so that the capacitor **22** is also charged at a faster rate and hence sooner terminates the irradiation.

In one embodiment the nominal wattage of the discharge tube was 190 Watts. The resistive value of the stabilising resistor **3** was approximately 76 Ohms. The resistor **7** had a value of approximately 840 kOhms. The resistor **10** had a value of approximately 22 MOhms. The value of the resistor **11** was approximately 10 MOhms. The value of the resistor **12** was approximately 10 MOhms. The resistor **13** likewise had a value of approximately 10 MOhms. The resistor **14** had a value of approximately 8.2 MOhms. The resistor **15** had a value of approximately 8.2 MOhms and the resistors **16** and **17** had values of approximately 5.6 MOhms and 8.2 MOhms, respectively. The values of the resistors **18** to **21** were 620 kOhms, 39 kOhms, 27 kOhms, 150 kOhms, respectively. The discharge resistor **26** had a value of approximately 10 kOhms. The capacitor **22** had a capacitance of approximately 3.3 μF. The capacitor **29** had a capacitance of approximately 47 μF. The capacitor **25** had a capacitance of approximately 0.33 μF. Due to its low capacitance this capacitor **25** was very quickly charged after closing the switch **5.** This capacitor has only a correcting function. It is achieved therewith that also during the half cycles when the terminal **1** is positive relative to the terminal **2** the voltage across the two potentiometers maintains a given value in case of a constant polarity. This is advantageous for controlling the device **28.**

In one embodiment a radiation quantity (for example expressed in Finsen minutes) was measured and was fixed at 100 at a nominal supply voltage of 220 Volt and a normally heating discharge tube. The table I denotes the measured quantity for the device according to the invention (expressed in percent of the nominal case referred to in the previous sentence) at other supply voltages namely at a 10% supply voltage increase (242 Volt) and at a 10% supply voltage decrease (198 Volt) as well as for slowly and quickly heating discharge tubes. These numbers are followed by corresponding values between brackets which were found in a device not according to the invention with a constant first-day irradiation time. The normal case is also fixed at 100. Table I shows that the irradiation quantity in a device according to the invention is maintained considerably more constant. Table II shows similar data as those in Table I. For Table II there applies, however, that this relates to a larger irradiation quantity, that is to say, a quantity corresponding approximately to the irradiation on the last day of a course of treatment. This Table shows that in a device according to the invention the quantity can be maintained constant in a very satisfactory manner which quantity may deviate only a few per cent from that of the desired quantity. This is considerably better than for a case not according to the invention whose numbers are listed in brackets.

TABLE I

Supply voltage in volts	Heating discharge tube Rapid	Normal	Slow	
242	113 (170)	103 (130)	93 (90)	first day
220	110 (140)	100 (100)	90 (60)	of irra-
198	106 (100)	96 (60)	86 (20)	diation.

TABLE II

Supply voltage in volts	Heating discharge tube Rapid	Normal	Slow	
242	104 (135)	101.5 (125)	99 (115)	last day
220	103.5 (110)	100 (100)	97.5 (90)	of irra-
198	102.5 (85)	100 (75)	97.5 (65)	diation

What is claimed is:

1. An irradiation device comprising a pair of input terminals, an electric discharge tube whose operating voltage increases after ignition, means connecting the discharge tube in series with a stabilising resistor across said input terminals of the device, means for shunting the stabilising resistor by an auxiliary branch comprising a first diode and a first non-capacitive impedance and having a tap, a timing circuit for automatic termination of the tube irradiation, means connecting a branch of the timing circuit in parallel with the discharge tube through the tap, characterized in that said first diode is present in the part of the auxiliary branch located between the discharge tube and the tap and the first non-capacitive impedance is present in the part of the auxiliary branch located on the other side of the tap, said branch of the timing circuit including at least a second similar noncapacitive impedance, an integrating member of the timing circuit being arranged across at least part of the second impedance for deriving a command signal for termination of the discharge tube irradiation, and means for limiting the direction of current flow through the first impedance of the auxiliary branch to a direction corresponding to the pass direction of the first diode.

2. An irradiation device as claimed in claim **1,** wherein said input terminals are adapted for connection to an alternating voltage supply and said means for limiting the direction of current flow through the first impedance in the auxiliary branch comprises a second diode arranged between the second impedance and the tap, the pass directions of the two diodes being in the same direction as viewed from the tap.

3. An irradiation device as claimed in claim **1** further comprising a switch in series with the discharge tube and the stabilizing resistor and wherein the integrating member includes a series arrangement of a first capacitor and a first variable resistor with said capacitor coupled to an auxiliary device associated with the timing circuit, the auxiliary device being operative in response to a given threshold voltage on the first capacitor to operate said switch and automatically terminate the operation of the discharge tube.

4. An irradiation device as claimed in claim **3,** characterized in that the first variable resistor comprises a first potentiometer and the second impedance comprises a second potentiometer with the wipers on the two potentiometers electrically interconnected.

5. An irradiation device as claimed in claim **3,** characterized in that the auxiliary device associated with the timing circuit comprises a parallel arrangement of a second capacitor, an energising winding of a relay and a switching amplifier, means connecting said parallel arrangement in series with a first current-limiting member and a third diode across the input terminals of the device, the contact of the relay being constituted by the switch in series with the discharge tube.

6. A circuit for operating an electric discharge tube comprising a pair of input terminals for coupling a source of supply voltage to the circuit, a ballast impedance connected in series with the discharge tube across the input terminals, a unidirectional switching device, a timing circuit for controlling the operation of the discharge tube comprising first and second impedance elements and an integrating member connected to the input terminals with a tap point between said first and second impedance elements connected to said discharge tube via said switching device so that a branch of the timing circuit including the second impedance element and the integrating member are arranged in parallel with the discharge tube, means for limiting the direction of current flow through said first impedance element in the pass direction of said unidirectional switching device, and means responsive to the voltage derived across the integrating member for terminating the operation of the discharge tube.

7. A circuit as claimed in claim **6** wherein said first and second impedance elements comprise resistors with said first impedance element and said switching device forming an auxiliary branch in parallel with the ballast impedance.

8. A circuit as claimed in claim **6** wherein said integrating member includes a capacitor and said tube operation terminating means comprises a switch having first and second positions, said first position of the switch being in series with the discharge tube and the ballast impedance across the input terminals to complete the current path from the input terminals to the discharge tube and said second position interrupting said current path while completing a closed loop circuit for the capacitor that includes a current-limiting impedance thereby to discharge the capacitor when the discharge tube operation is terminated.

9. A circuit as claimed in claim **6** wherein said switching device comprises a first diode and said means for limiting the direction of current flow comprises a second diode serially connected between said first and second impedance elements.

10. A circuit as claimed in claim **6** wherein said discharge tube is of the type that exhibits an increase in operating voltage for a period of time after ignition, said ballast impedance and said first and second impedance elements being chosen to provide a circuit voltage distribution such that the switching device initially couples the discharge tube operating voltage to the timing circuit upon ignition of the tube and subsequently decouples said tube operating voltage therefrom when the tube reaches a voltage level approximating its nominal operating value.

11. A circuit as claimed in claim **10** wherein said means for terminating the tube operation comprises, a capacitor, a relay winding and a controlled switching device connected in parallel, said relay winding controlling the operation of a contact in series with the discharge tube, and means connecting said parallel arrangement in series with a third impedance element and a diode across the input terminals.

12. A circuit as claimed in claim **10** wherein said second impedance element comprises a variable resistor and said integrating member comprises a capacitor, said first impedance element, said variable resistor and said capacitor being serially connected across the input terminals in the order named.

13. A circuit as claimed in claim **12** wherein the timing circuit includes a second variable resistor in series with the capacitor and the first impedance element, said first and second variable resistors having wiper arms electrically interconnected.

14. A circuit as claimed in claim **10** wherein said switching device comprises a first diode, a second diode, and means connecting said first impedance element, said second diode, said second impedance element and said integrating member in series circuit across the input terminals such that the first impedance element and the first diode form a series circuit in shunt with the ballast impedance and the second diode, the second impedance element and the integrating member form a series circuit shunting the discharge tube with said first and second diodes oppositely poled in the closed loop circuit formed by the discharge tube, the diodes, the second impedance element and the integrating member.

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