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FIRING CIRCUIT FOR VOLTAGE REGULATOR TUBE

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FIG. 1

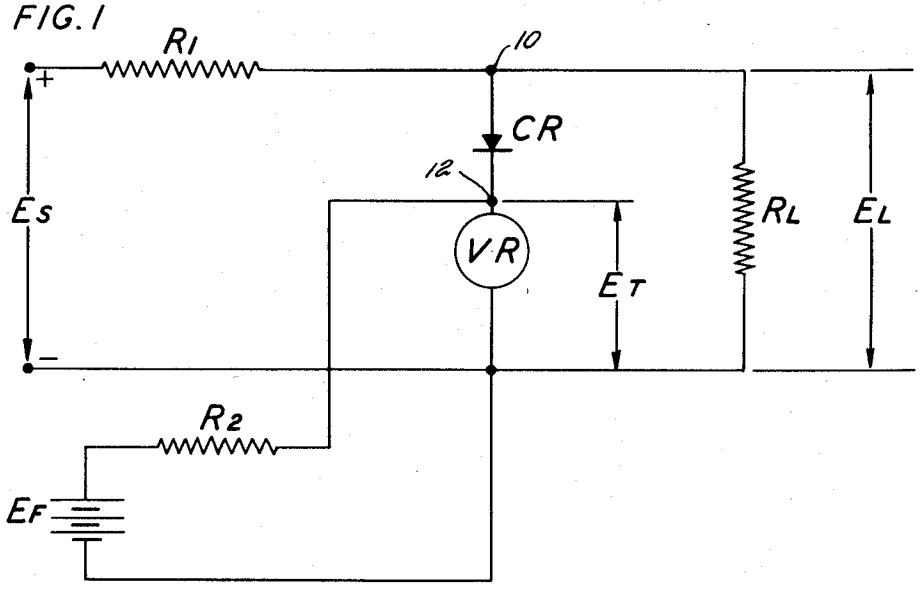
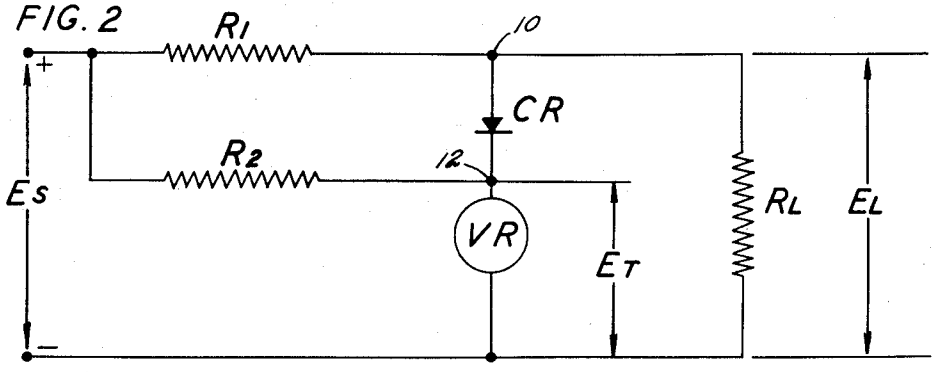


FIG. 2



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FIRING CIRCUIT FOR VOLTAGE REGULATOR TUBE

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This invention relates to voltage regulator circuits and particularly to circuits utilizing gaseous discharge tubes including the firing circuits for the tubes.

An object of this invention is a circuit for firing a gaseous discharge tube and also limiting the loss in the line.

A further object is a circuit utilizing the available line voltage for firing the tube and limiting the tube running load to a minimum.

A further object is a circuit utilizing a single power source and separate lines for firing the tube and for supplying the load so that the power loss will be maintained at a minimum.

Other objects and advantages will be apparent from the following specification and attached drawings in which:

Fig. 1 is a circuit diagram incorporating a voltage regulator including the firing circuit of the invention.

Fig. 2 is a circuit diagram incorporating the invention utilizing the line voltage for firing the voltage regulator tube.

In voltage regulator tube circuits having a material voltage source variation in which the minimum source voltage is above the firing voltage, it becomes important to maintain the dropping resistance between the source and the voltage regulator tube at a maximum to keep the total current through the dropping resistor at a minimum and only slightly above the load current. Normally where the line voltage is used to fire the tube the optimum dropping resistance cannot be used because the dropping resistance and the load resistance forms a voltage divider circuit which will determine the voltage supply available at the junction of the two resistors, where the voltage regulator tube is normally connected. In order to obtain the necessary comparatively high voltage supply to fire the tube, especially where the line voltage is only slightly above the voltage necessary for firing, the dropping resistor must be made small in order to still have available at the junction of the dropping and load resistors, where the voltage regulator tube is connected, a voltage supply high enough to fire the tube. With such a small dropping resistor, the current through the dropping resistor and the tube becomes excessive when the tube starts to conduct, resulting in a high I^2R loss through the resistor or an overloading of the tube or both. If the resistance is made large enough to prevent the tube from overloading, it will then drop the line voltage so much that at the minimum line voltage there will not be voltage supply enough left at the junction of the dropping and load resistances to fire the tube.

In order to permit the use of an optimum dropping resistance in the operating circuit, I have provided a separate circuit for firing the tube, thus allowing the dropping resistor to be the optimum resistance for limiting the current through the voltage regulator tube to a minimum while providing sufficient current to provide the necessary regulation.

In Fig. 1 the direct current source voltage is indicated

at E_S, the dropping resistor R_1, the voltage regulator tube VR, the load resistant R_L, and the load or regulated voltage supply E_L. The voltage regulator tube is connected at 10 between the dropping resistance R_1 and the load resistance R_L and a rectifier CR is inserted in the line between the connection 10 and the voltage regulator tube. A second source of voltage E_F is connected through a dropping resistor R_2 to the voltage regulator tube at point 12 so that the rectifier CR isolates this second source of voltage E_F from the load resistance.

Before the voltage regulator tube starts to conduct, it acts as an open circuit to both the source voltage E_S and the auxiliary voltage E_F. There will be some current flow through R_1 and R_L from the source E_S which will make the voltage supply at 10 somewhat less than the E_S voltage source. There will be no current flow through R_2 because the rectifier will block current flow through R_L and the voltage regulator tube is not conducting; therefore, the full voltage of E_F will be applied across the rectifier tube to fire it and the resistance R_2 can be made high to limit the current flow through the voltage regulator tube to the desired amount. As the resistance R_1 is not utilized in firing the tube, it can be made at the optimum value to supply the desired running voltage or voltage supply at point 10 with the optimum amount additional current over the load current to provide satisfactory operation of the voltage regulator tube.

The voltage regulator tube has a range of currents at which it will satisfactorily operate in regulating. By utilizing the above system in which a portion of the current is supplied from E_F through R_2 and the remainder of the current is supplied from E_S through R_1, it is possible to design the resistors R_1 and R_2 so that an optimum current flow through the regulator tube will be sufficient to supply the necessary voltage drop from the source E_S to the voltage supply point 10 to provide the desired regulation even where the source E_S has a material variation, from from 90 to 120 volts. The rectifier CR will of course transmit current from the source E_S through the regulator tube when the voltage regulator tube is conducting as both the rectifier CR and the regulator tube VR are connected to conduct in the same direction.

Where the voltage of the power source is equal to or above the firing voltage, it is possible to use this source instead of an auxiliary source for firing the tube and still have the resistance R_1 an optimum resistance.

Fig. 2 shows the source voltage connected in a separate firing circuit to fire the voltage regulator tube with this second circuit incorporating the resistance R_2 and isolated from the load resistance by the rectifier CR so that before the voltage regulator tube starts to conduct, the full voltage of the source may be applied as a voltage supply across the voltage regulator tube to fire the tube and after the tube starts to conduct then the source E_S through the resistor R_1 can supply the operating circuit the voltage to be regulated with the resistor R_1 chosen to provide the minimum power loss while maintaining an efficient operation of the voltage regulator tube. As before the resistance R_2 can be chosen to provide a minimum power loss while assisting in the efficient operation of the voltage regulator tube. The rectifier CR, as before, will act to isolate the circuit including the resistance R_2 from the load circuit.

The convention used for the rectifier is that of current as that opposed to electron flow and the arrow of the rectifier is shown in the direction of current flow from plus to minus.

From the above it will be apparent that I have provided either two separate sources of voltage connected in parallel to the voltage regulator tube and separated by a rectifier or a single source of voltage with two parallel paths to the voltage regulator tube separated by a

rectifier thus providing one circuit for firing the tube, which circuit can be designed with an optimum resistance for low loss and efficient tube operation and a second circuit for providing the voltage to be regulated with a dropping resistor which can also be designed for a minimum power loss with efficient voltage regulation within the operating limits of the tube current.

It is to be understood that the invention is not limited to the specific embodiment herein illustrated and described, and may be used in other ways without departure from its spirit as defined by the following claims.

I claim:

1. In combination a direct current power source, a load connected across said source, a voltage regulator tube and a rectifier in series connected across said source in parallel with said load, means modifying the potential of said source in accordance with current flow through said load and rectifier, a connection, including means modifying the potential of said source in accordance with current flow, connecting said source directly across said tube to provide a firing circuit for said tube.

2. In combination a source of direct current, two parallel connections from said source each having means dropping voltage in accordance with current flow through the respective connection, a voltage regulator tube connected directly across one said connection and connected in series with a rectifier conducting in the same direction as said tube across the other connection.

3. In combination, a gas tube having a relatively stable forward voltage drop and a preferred range of variable current characteristics, a rectifier having a relatively low forward resistance and a relatively high back resistance connected in series so that both the tube and the rectifier have the same forward direction, a load connected across said series arranged tube and rectifier, an impedance connecting said series arranged tube and rectifier, and said load in parallel, across a source of power, having a voltage higher than the tube firing voltage to regulate the voltage applied to said load by controlling the voltage drop between said source and said tube and load, said impedance selected to provide the optimum operating conditions and the preferred range of variable current in said tube, said impedance dropping the voltage of said source to below the firing voltage of said tube due to the current flow through said load when said tube is not operating, a relatively high impedance arranged in a firing circuit receiving its entire voltage from said source and connected directly across said tube and said source in parallel with the circuit containing the first mentioned impedance and isolated from said load by the rectifier to supply a voltage from said source to said tube unaffected by current flow through the load to fire the tube.

4. In combination with a direct current operating circuit comprising, a series arranged direct current voltage source, dropping resistor and load, a voltage regulator tube having a working voltage less than the direct current voltage of said source and a rectifier conducting in the same direction connected in series across said load and across said series arranged dropping resistor and direct current voltage source to be regulated and means for firing said tube comprising, a voltage supply, including means for limiting current flow, connected directly across said tube in parallel with said dropping resistor, said voltage source supplying all the voltage for said voltage supply.

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