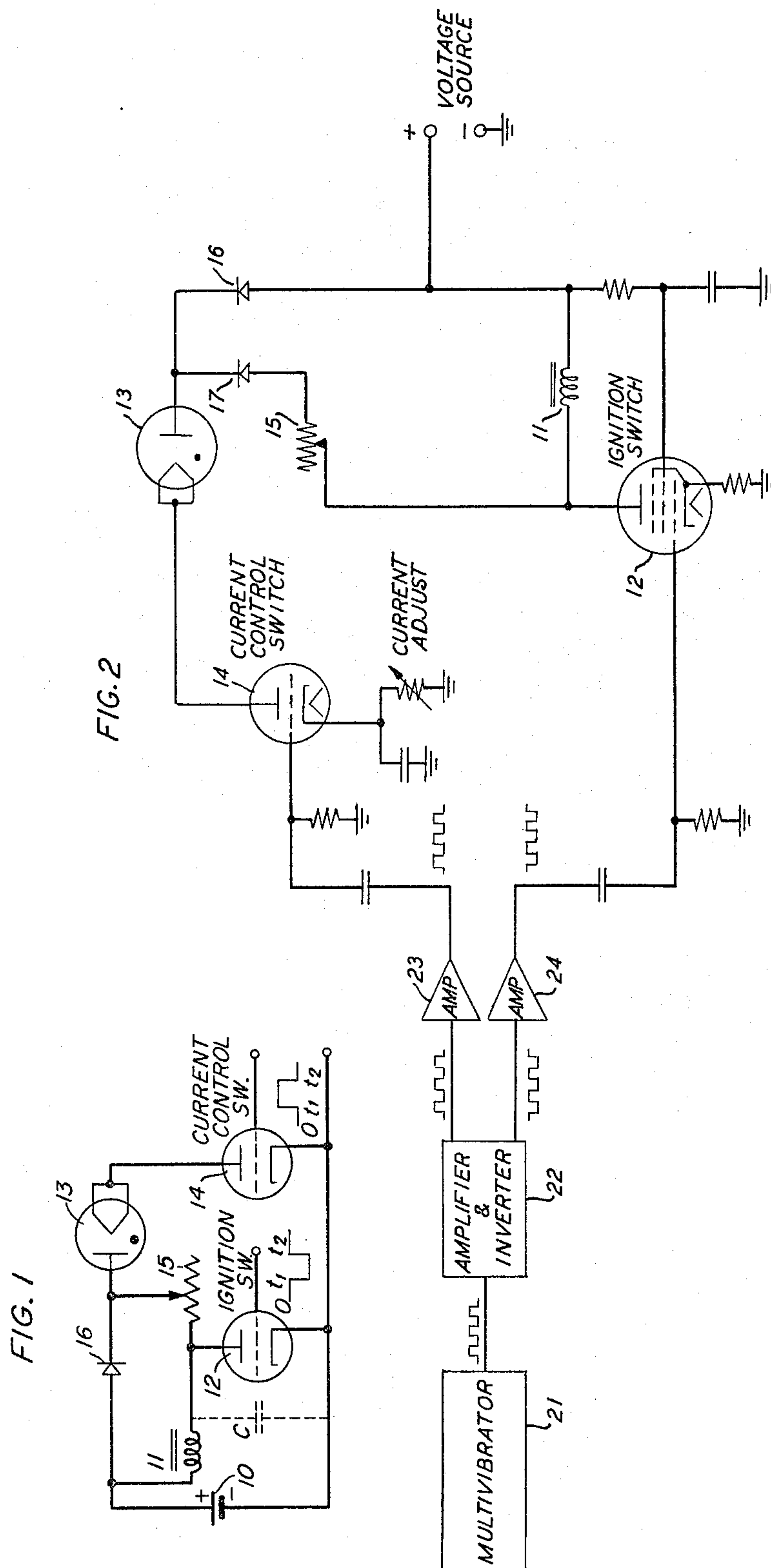


Oct. 11, 1966

W. W. SNELL, JR
IGNITION AND CURRENT CONTROL SYSTEM FOR
GAS DISCHARGE DEVICES
Filed June 21, 1963

3,278,800



1

3,278,800

IGNITION AND CURRENT CONTROL SYSTEM FOR GAS DISCHARGE DEVICES

William W. Snell, Jr., Middletown Township, Monmouth County, N.J., assignor to Bell Telephone Laboratories, Incorporated, New York, N.Y., a corporation of New York

Filed June 21, 1963, Ser. No. 289,485

3 Claims. (Cl. 315-209)

This invention relates to electrical circuits employing gas discharge tubes and, in particular, to means for igniting such tubes.

In United States Patent 2,706,782, issued to W. W. Mumford, the use of a gas discharge tube as a broadband microwave noise source is described. Such tubes can be ionized, and caused to conduct current by the application of a suitably large voltage. If the tube is to be pulsed on and off, ignition is obtained by the application of this high ignition voltage followed by a control voltage suitable for one pulsed cycle. The difficulty with this mode of operation, however, is that it can produce an undesirable, high, power transient which causes ionic bombardment of the filament. This bombardment can be so severe that bright eruptions at the filament can be observed visually. These have the effect of causing an uneven noise output from the tube and of greatly shortening the filament life.

It is, accordingly, an object of this invention to prevent high power transients in gas discharge devices during ignition.

It is a more specific object of this invention to decouple the high voltage ignition source from the gas discharge device immediately following ignition.

In accordance with the invention, electrical energy is supplied to a gas discharge device from two separate, parallel connected circuits. The first, called the current control circuit, includes the series arrangement of a diode, poled to permit current flow from a voltage source to the gas discharge device, the device itself and a current control switch. The second circuit includes the series arrangement of an inductor and an ignition switch. The two circuits are interconnected by means of a current limiting element such as a resistance.

With the current control switch open and the ignition switch closed, current flows from the voltage source through the inductor. To initiate current flow in the device, the current control switch is closed and the ignition switch is simultaneously opened, tending to cut off the current through the inductor. This results in a voltage build-up across the inductor which is transmitted to the discharge device through the interconnecting current limiting element.

When the voltage across the discharge device reaches the ignition voltage for the device, ignition occurs. Power transients in the discharge device are maintained at a safe level by the action of the current limiting element which controls the instantaneous power that can be supplied from the ignition circuit. Following ignition, current is supplied to the gas discharge device through the diode.

These and other objects and advantages, the nature of the present invention, and its various features, will appear more fully upon consideration of the various illustrative embodiments now to be described in detail in connection with the accompanying drawings, in which:

FIG. 1 shows an ignition circuit in accordance with the invention; and

FIG. 2 shows a practical embodiment of the ignition circuit shown in FIG. 1.

Referring to FIG. 1 there is shown an ignition circuit,

2

in accordance with the invention, comprising a pair of parallel paths interconnected by means of a resistance. The first path, which is the ignition circuit, comprises, in series, a constant (D.C.) voltage source 10, an inductor 11 and an ignition switch which, for purposes of illustration, can be a vacuum tube 12.

The second path, which is the current control circuit, comprises, in series, the voltage source 10, a diode 16, the gas discharge tube 13 and a current control switch which, for purposes of illustration, is also shown as a vacuum tube 14.

The ignition circuit is coupled to the gas discharge tube 13 by means of a current limiting resistance 15, shown as a potentiometer which, as will be explained hereinbelow, also decouples the ignition circuit from the gas discharge tube after ignition.

Also shown dotted in FIG. 1 is the capacitor C which represents all the stray capacitance associated with the ignition circuit. Although C may be small (of the order of micro-microfarads, its presence can have a potentially harmful effect on the gas tube in the absence of the special precautions described herein in accordance with the teachings of the invention.

The ignition of gas tube 13 can be understood by referring to FIG. 1 and considering the following sequence of steps:

During the period between time $t=0$ and $t=t_1$, tube 12 is biased into conduction, causing current to flow through inductor 11 and tube 12 thereby storing energy in the form of a magnetic field around inductor 11. During this period current control tube 14 is biased off.

Ignition is achieved by simultaneously reversing the bias on tubes 12 and 14 at time t_1 . This cuts tube 12 off, causing the current through inductor 11, and hence the magnetic field around inductor 11, to decrease. Correspondingly, the voltage across inductor 11 builds up. The voltage rise, caused by the collapsing magnetic field around the inductor, is impressed across the gas tube 13.

Since there is no current flow through the gas tube until the ignition voltage is reached and ionization occurs, all of the inductor current goes to charging the stray capacitance C. When the voltage across the gas tube 13 reaches the ignition voltage, tube 13 fires, dropping its impedance R_L to some low value (typically of the order of several hundred ohms). In prior art ignition systems, this rapid resistance transition was accompanied by the discharge, through the gas tube, of the charge stored in capacitor C. This produced an undesirable, high, power transient through the gas tube which resulted in ionic bombardment of its filament. Since this bombardment was repeated whenever ignition occurred, the filament life was greatly shortened.

In accordance with the invention, however, the charge stored in the stray capacitance C is not discharged directly into the gas tube but, instead, is largely dissipated in the current limiting resistance 15. To illustrate this, let it be assumed that the ionization potential E across C remains constant and that the resistance of tube 14 is negligible. The ignition current is then given by

$$I = \frac{E}{R + R_L} \quad (1)$$

where R_L is the resistance of the gas tube after ignition, and R is the amplitude of the resistance 15.

The ignition power dissipated in the gas tube is $I^2 R_L$ and is a maximum when $R_L = R$. Thus,

$$P_{\max} = \frac{E^2}{4R} \quad (2)$$

Since it was assumed that the ignition voltage is constant, the maximum ignition power dissipated is a function

3

of R. Conversely, the value of R to limit the ignition power to a predetermined value P is

$$R \geq \frac{E^2}{4P} \quad (3)$$

Preferably, P is equal to, or less than, the maximum average rated power of the discharge tube.

Assuming tube 13 is a TD-11 argon lamp having a rated average of power of 15 watts and an ignition voltage of 1500 volts, we get, from Equation 3, that

$$R \geq \frac{(1500)^2}{4(15)} = 37,500 \text{ ohms}$$

In practice it was found that reliable ignition was achieved when R was equal to 350,000 ohms, or nearly ten times the minimum value given by Equation 3. From Equation 2 the corresponding value of $P_{\max}$ is only 1.6 watts.

After ionization, the current control tube 14 allows an adjustable amount of current to flow through the gas tube 13 for the remainder of the on period. The current flows from the voltage source 10 through diode 16. The latter diode is chosen to withstand a high peak inverse voltage equal to, at least, the ignition voltage. The current flow continues until time t_2 when tube 14 is again biased beyond cutoff and tube 12 is biased into conduction. The ignition process is repeated at the beginning of the next on period.

A second diode (not shown) can be inserted in series with R to reduce the current ripple in the gas tube due to oscillations in the voltage across C. These ripples are due to the resonance of inductor 11 with the stray capacitance. In particular, the oscillating voltage is decoupled from the gas tube during its negative excursions. A diode in series with R also insures that the charging current is not shunted around the inductor when tube 12 conducts. However, for large values of R, a series diode is generally not required although its inclusion does no harm.

FIG. 2 shows, in somewhat greater detail, an ignition system in accordance with the invention. The ignition and current control switches are again shown as vacuum tubes 12 and 14, respectively. All other components common to FIG. 1 and FIG. 2 use the same identification numerals. In addition, a diode 17 is shown in series with resistance 15 for the reasons set forth hereinabove.

4

Timing pulses for fixing the on and off periods are derived from a multivibrator 21 which drives an amplifier-phase inverter 22. The output from the latter is fed to a pair of amplifiers 23 and 24 which drive the current control tube 14 and the ignition tube 12 to cut off and into conduction with out-of-phase voltages.

In all cases it is understood that the above-described arrangements are illustrative of a small number of the many possible specific embodiments which can represent applications of the principles of the invention. Numerous and varied other arrangements can readily be devised in accordance with these principles by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. An energizing circuit for a gas discharge tube comprising:

means forming a pair of parallel current paths;

the first of said paths including, in series, a voltage

source, a diode, said tube and a current control switch;

the other of said paths including, in series, said voltage

source, an inductor and an ignition switch;

current limiting means connecting the junction of said

diode and said tube to the junction of said inductor

and said ignition switch;

and means for simultaneously opening said ignition switch and closing said current control switch.

2. The circuit according to claim 1 wherein said current limiting means is a resistance whose amplitude R is given by

$$R \geq \frac{E^2}{4P}$$

where E is the ignition voltage of said tube and P is the maximum power to be dissipated in said tube at ignition.

3. The circuit according to claim 1 wherein said current limiting means comprises, in series, a resistance and a diode.

References Cited by the Examiner

UNITED STATES PATENTS

2,480,681	8/1949	Stiefel	315—100
2,916,671	12/1959	Retzer	315—176

JOHN W. HUCKERT, *Primary Examiner*.

L. ZALMAN, J. D. CRAIG, *Assistant Examiners*.