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GAS DISCHARGE TUBE PULSING CIRCUIT

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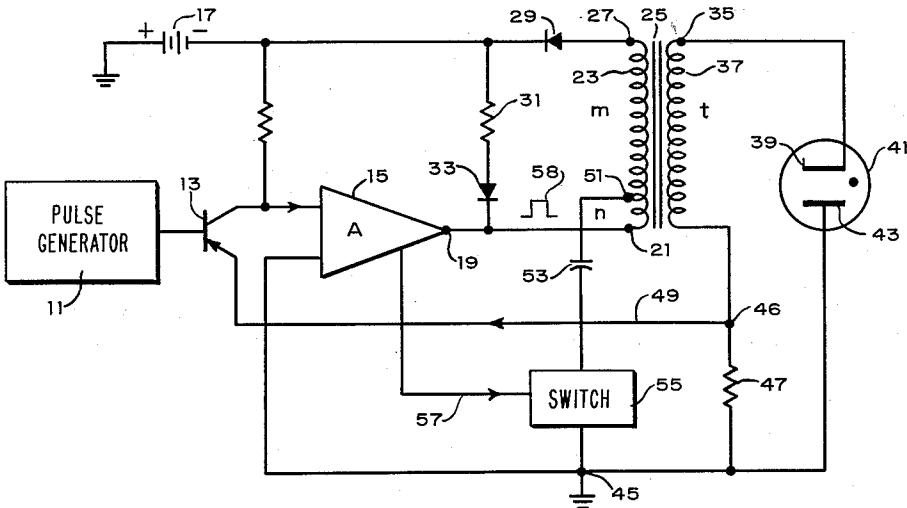


Fig. 1

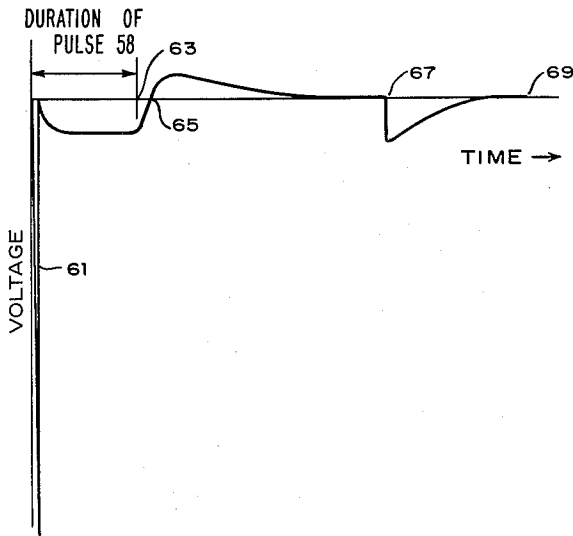


Fig. 2

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GAS DISCHARGE TUBE PULSING CIRCUIT

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This invention relates to circuits for pulsing gas discharge tubes and other devices having similar electrical properties.

Certain microwave noise sources use elongated gas discharge tubes having a firing voltage of several thousand volts and a sustaining voltage of approximately 150 volts. While they are in their fired condition, these tubes may pass a current of the order of .2 ampere. One way to supply sufficient voltage and current to operate these gas discharge tubes would be to use a transformer whose secondary can supply .2 ampere and 2000 volts. To do so, however, would require a primary which, when connected across a 115-volt supply, could carry 3.5 amperes. Primary circuit components such as transistors would have to have high current ratings and would therefore be quite expensive.

An object of this invention is to overcome these drawbacks by providing a circuit which can supply both a high voltage spike for igniting a gas tube and the current for sustaining said ignition, without requiring a prohibitively high current in the primary winding of a transformer.

Microwave noise sources are used in such a manner that it is highly desirable to control accurately the duration of noise pulses. It is therefore desirable to provide means to provide a fast decay of the gas tube discharge when the tube is turned off.

It is therefore another object of this invention to provide a circuit which allows the discharge of a gas tube to decay rapidly when the tube is turned off.

Other and incidental objects of this invention will be apparent from a reading of this specification and an inspection of the accompanying drawing in which:

FIGURE 1 is a diagram of a gas tube modulating circuit in accordance with this invention, and

FIGURE 2 is a graph showing the voltage across the gas tube plotted as a function of time.

Referring to FIGURE 1 there is shown a pulse generator 11 supplying positive-going pulses to the base of transistor 13. Transistor 13 is the input stage of amplifier 15, suitable operating potentials being provided by the direct-current power supply or battery 17. The positive-going output pulse available at the output terminal 19 of amplifier 15 is applied to the lower terminal 21 of the primary winding 23 of transformer 25. The upper terminal 27 of transformer 25 is connected to the negative terminal of power supply 17 through a unilateral conduction device such as diode 29. A series-circuit comprising resistor 31 and diode 33 is connected in parallel with the series-circuit comprising diode 29 and primary winding 23. The upper terminal 35 of the secondary winding 37 of transformer 25 is connected to the cathode 39 of the gas tube 41 which is to be pulsed. The anode 43 of tube 41 is connected to the grounded terminal 45 of power supply 17, and the lower terminal 46 of secondary winding 37 is connected to grounded terminal 45 through a resistor 47. A feedback lead 49 is provided from the terminal 46 to the emitter of transistor 13. The primary winding 23 is provided with a tap 51 which is connected to terminal 45 through capacitor 53 and normally closed switch 55. Switch 55 is actuated by signals coming over lead 57 from amplifier 15.

The operation of the circuit shown in FIGURE 1 will be explained with reference to the waveform shown in

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FIGURE 2. A positive-going pulse from the pulse generator 11 is amplified by the input stage 13 and the amplifier 15. Amplified pulse 58 is applied without polarity reversal to the primary winding 23. As the switch 55 is normally closed, and the capacitor 53 presents a low impedance high-frequency path to ground, the pulse 58 appears across that portion of the primary winding 23 comprised between terminal 21 and tap 51. Let us call n the number of turns between terminal 21 and tap 51, m the number of turns between tap 51 and terminal 27, and t the number of turns in the secondary winding 37. The voltage pulse across the secondary winding 37 is t/n times the voltage pulse 58. Since the primary winding 23 acts as an autotransformer, there is a voltage pulse between tap 51 and terminal 27 which is equal to m/n times the voltage pulse 58. The voltage pulse across tap 51 and terminal 27 is isolated from the power supply 17 by the diode 29. There is thus a high voltage output pulse 61 available across the secondary winding 37 for firing the tube 41. The operation up to this point is similar to that which would be obtained had the transformer 25 had a turns ratio of t/n .

At the instant the gas tube fires, the current drain in the secondary increases sharply. This causes the current in the lower portion of the primary to increase and the capacitor 53 to change rapidly. When the voltage between points 21 and 51 drops sufficiently, the diode 29 conducts and current flows through the entire primary winding 23. The primary current is then only $t/m+n$ of I_0 , where I_0 is the current required by the gas tube 41 when in its fired condition. The operation now is similar to that which would be obtained with a transformer 25 having a turns ratio of $t/m+n$. If we assume that $t/m+n=10$, $t/n=100$, pulse 58=40 volts and $I_0=.2$ ampere, the output voltage spike is 4000 volts while the primary current to operate the tube is only 2 amperes, instead of the 20 amperes that would be necessary if use were made of a standard circuit with a transformer having a t/n turns ratio.

In order to regulate the current I_0 through tube 41 (and therefore its noise output), negative feedback is provided from terminal 51 back to the emitter of input stage 13. This feedback is present only during the time the gas tube 41 conducts. This allows the amplifier 15 to be driven to its maximum output at the instant of ignition with a relatively small input signal.

When the pulse 58 terminates, that is at time 63 of FIGURE 2, the current supplied to terminal 21 of the primary winding goes to zero and remains at zero, the output impedance of the amplifier being very large. Simultaneously the switch 55 is opened by a signal derived from an interstage transformer of the amplifier 15 and applied to switch 55 over lead 57. The current in the primary winding is zero, and the resistive diode path in the primary is non-conducting as long as pulse 58 is positive. The gas tube discharge will therefore decay very fast between times 63 and 65, since the only energy available to maintain the discharge is that stored in the transformer leakage inductance and distributed capacitances, and part of this energy is being continuously transferred to the transformer core.

When the voltage across tube 41 reaches zero (at time 65), the transformer core discharges through the resistive diode path in the primary, causing the voltage across tube 41 to rise and decay as shown between times 65 and 67. At time 67 the switch 55 closes. The signal to switch 55 is derived from the interstage transformer in amplifier 15. This interstage transformer has its core charged by the input pulse. At the end of the input pulse, the flux in the core started to collapse. The signal obtained from the end of this collapse closes the switch 55. There is a residual charge on capacitor 53. The

closing of switch 55 causes the capacitor 53 to discharge, and there appears across the secondary winding a signal multiplied by the t/m turns ratio. This signal shown between times 67 and 69 is well below the voltage necessary to ignite the tube 41.

I claim:

1. A circuit for pulsing a gas discharge tube, said circuit comprising a transformer having primary and secondary windings, said primary winding having two terminals and a tap thereon, means to connect said gas discharge tube across said secondary winding, direct-current power supply means having two terminals, means including a unilateral conduction device to connect one terminal of said primary winding to one terminal of said power supply, means including a capacitor and a normally-closed switch to connect said tap to the other terminal of said power supply, a pulse generator, means to connect said pulse generator to the other terminal of said primary winding, and means responsive to the termination of a pulse from said generator to open said switch.

2. A circuit for pulsing a gas discharge tube, said circuit comprising a transformer having primary and secondary windings, said primary winding having two terminals and a tap thereon, means to connect said gas discharge tube across said secondary winding, direct-current power supply means having positive and negative terminals, means including a unilateral conduction device to connect one terminal of said primary winding to one terminal of said power supply, said unilateral conduction device being connected with such polarity as to allow the flow of current from said power supply to said primary winding, means including a capacitor and a normally-closed switch to connect said tap to the other terminal of said power supply, a pulse generator, means to connect said pulse generator to the other terminal of

said primary winding and apply a pulse thereto with such polarity as to oppose conduction in said unilateral conduction device, and means responsive to the termination of a pulse from said generator to open said switch.

3. A circuit for pulsing a gas discharge tube, said circuit comprising a transformer having primary and secondary windings, said primary winding having two terminals and a tap thereon, means including a series resistor to connect said gas discharge tube across said secondary winding, direct-current power supply means having positive and negative terminals, means including a unilateral conduction device to connect one terminal of said primary winding to one terminal of said power supply, said unilateral conduction device being connected with such polarity as to allow the flow of current from said power supply to said primary winding, means including a capacitor and a normally-closed switch to connect said tap to the other terminal of said power supply, a pulse generator, means including an amplifier to connect said pulse generator to the other terminal of said primary winding and apply a pulse thereto with such polarity as to oppose conduction in said unilateral conduction device, means responsive to the termination of a pulse from said generator to open said switch, and negative feedback means connected between said secondary winding and said amplifier.

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