

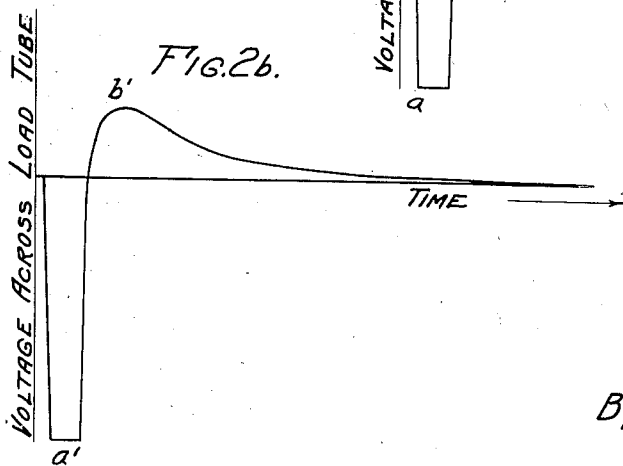
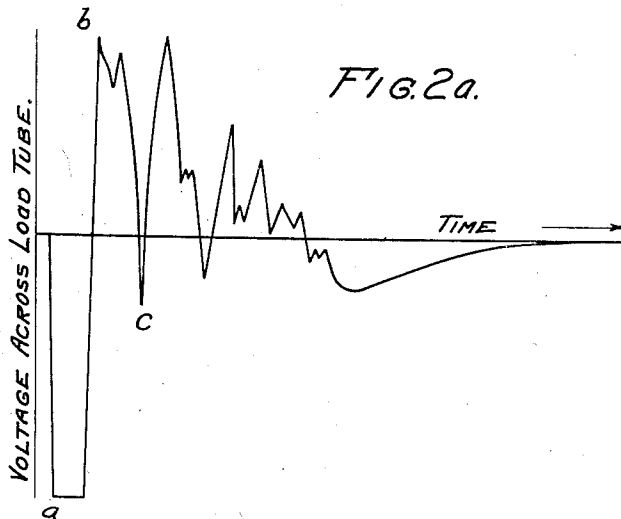
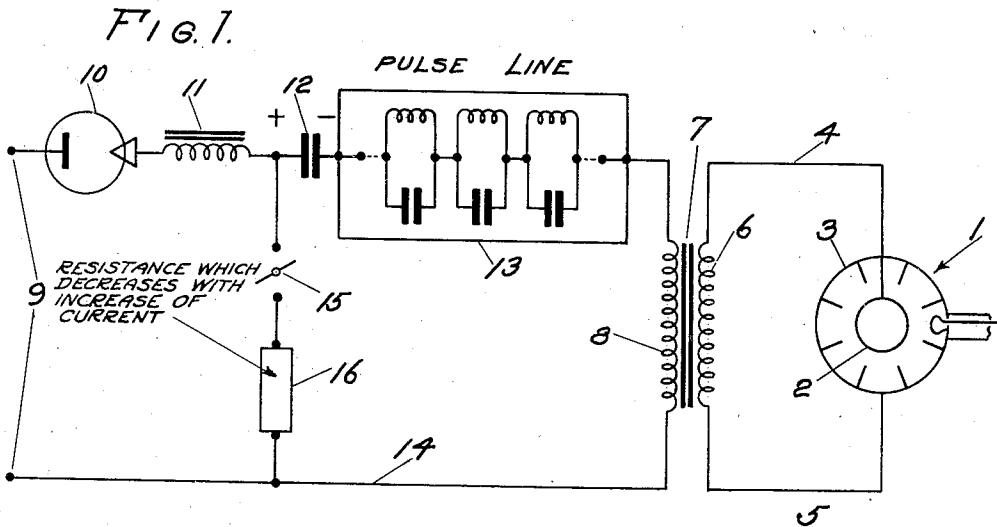
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PULSING SYSTEM FOR ULTRA HIGH FREQUENCY GENERATORS

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PULSING SYSTEM FOR ULTRA HIGH
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This invention relates to an electrical system adapted to produce pulses of ultra high frequency oscillations and a method of generating such pulses.

For certain purposes, for example, in pulsing applications in radar equipment, an ultra high frequency generator is energized intermittently to conduct peak currents. In some pulsing applications the ultra high frequency generator may be energized as frequently as 1,000 times per second and the duration of each energization may be of the order of a microsecond. Thus, the intervening period between energizations may be of the order of 1,000 microseconds, more or less, which period is long compared to the duration of the energization, and during this intervening period the ultra high frequency generator should remain inactive.

A convenient source of current for energizing the ultra high frequency generator for such short intermittent periods is a condenser or other energy storage device. However, in prior attempts to derive the energy for the energization of the ultra high frequency generator from the discharge of a condenser, difficulties have been encountered in that the discharge circuit of the condenser may be oscillatory. In such a case the oscillatory discharge may energize the ultra high frequency generator several times in rapid succession instead of providing a single energization followed by the relatively long pause period. These undesirable impulses of current from the oscillatory discharge of the condenser are, of course, at a much lower energy level than the initial and desired impulse and this results in the energization of the ultra high frequency generator at a correspondingly low energy level so that relatively weak undesired oscillations are generated thereby. Since these weak oscillations may be mistaken for a reflection of the wave or waves generated during the initial phase of the energization of the oscillator, they are sometimes referred to as "false echoes" and will be hereinafter so designated for the sake of brevity. When it is attempted to eliminate these false echoes by providing that the discharge circuit of the condenser be non-oscillatory in accordance with the familiar expression

$$R^2 > \frac{4L}{C}$$

where R is the resistance, L the inductance, and C the capacitance of the circuit, it is found that the resulting circuit is unsatisfactory in that it imposes too great an impedance to the current during the initial impulse. Thus, at a time when it is desired to supply energy to the ultra high frequency generator, for example a magnetron, and when the resistance of this device is relatively low, since the device is at this time conductive,

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the total resistance of the circuit is high and accordingly a large portion of the energy of the impulse is lost in the high resistance of the circuit.

It is among the objects of the invention to overcome the difficulties mentioned in the foregoing and provide a system for the production of pulses of ultra high frequency oscillations in which the energy of the impulses to the ultra high frequency generator will not be unduly impeded at times when it is desired that the generator be conductive and to impose a high impedance at other times.

It is also among the objects of the invention to eliminate the false echoes described in the foregoing.

It is a further object of the invention to improve the efficiency of systems of the type described and insure that strong pulses of ultra high frequency oscillations will be generated without undue losses in the system.

The above and other objects and features of the invention will be made fully apparent to those skilled in the art from a consideration of the following detailed description taken in conjunction with the accompanying drawing in which:

Fig. 1 is a schematic diagram of an electrical system embodying my invention;

Fig. 2a is a curve representing certain operating characteristics of a system of this type as they would be without the use of my invention; and

Fig. 2b is a curve representing certain operating characteristics of the system of this invention where my invention is utilized.

Referring to the drawing and first to Fig. 1 thereof, the embodiment of the invention illustrated includes an ultra high frequency oscillator which may be of any suitable type. In the instance shown the generator is of the magnetron type having a cathode 2 and an anode 3, which anode is in the form of a cylinder having inwardly projecting radial arms providing a plurality of anode faces coacting with the cathode 2 in a well-known manner. The cathode 2 and anode 3 are connected by conductors 4 and 5, respectively, to opposite ends of a secondary winding 6 of a transformer 7 having a primary winding 8. The primary winding 8 is adapted to be supplied with pulses of current from any suitable source, which may be either alternating or direct, connected to the terminals 9. A rectifier and blocking tube 10, which may be of the thermionic type, has its anode connected to one of the terminals 9, and its cathode connected by way of a choke 11 to one side of a condenser 12. The opposite side of the condenser 12 is connected by way of a pulse line 13, the primary winding 8, and a conductor 14 to the other terminal 9. A spark gap 15 has one terminal thereof connected to the positive side of the condenser 12

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at a point between said condenser and the choke 11, and its other terminal connected by way of resistor 16 to the conductor 14. The resistor 16 is of the type having negative resistance-current characteristics; that is to say, the resistance 16 is of the type in which the resistance falls as the current therethrough increases. Preferably, the resistor 16 is a device of the type the resistance of which varies as the negative non-linear function of the current therethrough, so that as the current increases from zero the resistance decreases very sharply. Devices having resistance-current characteristics suitable for the purpose of this invention are known per se. For example, the device may be of the type known as "Thyrite" formed of a mass of silicon carbide crystals or similar material suitably bound together.

In operation, assuming that the condenser 12 has been charged through the rectifying and blocking tube 10, when the spark gap 15 fires the condenser 12 discharges through the resistance 16, the primary winding 8 of the transformer 7, and the pulse line 13. The pulse line 13 functions in a manner which is known per se to give the pulse of current from the discharge of the condenser a rectangular form. This pulse of current induces a pulse in a secondary winding 6 which flows through conductor 5 to the anode 3 and thence to the cathode 2 and back to the opposite end of the secondary 6 by way of conductor 4.

The nature of the initial impulse derived from the discharge of the condenser 12 may be more readily comprehended by referring to the curves shown in Figs. 2a and 2b. In these curves the voltage across the tube is indicated as the ordinate, and time as the abscissa of a coordinate system. It will be understood that while the curves indicate in a general way certain qualitative characteristics of the electrical system, they are not intended to indicate these characteristics in a quantitative sense.

Referring to the curve shown in Fig. 2a, upon the closure of the spark gap 15 a voltage is impressed across the load tube 1 in the direction in which the tube is conductive, which voltage increases sharply and remains relatively constant for a short period to provide the energization impulse *a*. During this period the tube is conductive and functioning to generate ultra high frequency oscillations. After a short period, during which the impressed voltage is substantially constant, the voltage tends to reverse rapidly. If the resistance 16 were of the usual type and the characteristics of the circuit such that

$$R^2 < \frac{4L}{C}$$

then the voltage would tend to rise sharply to a high peak as indicated at *b* in the curve. This voltage would be impressed on the tube in an inverse direction and during the period of this inverse voltage the tube 1 would be non-conductive. Because of the oscillatory character of such a circuit the voltage would again tend to reverse and cause an undesired voltage peak *c* to be impressed across the tube 1 again in the direction in which the tube is conductive. The tube 1 would thus be energized to generate relatively weak undesired oscillations in the nature of a false echo of the desired pulse of oscillations generated by the tube 1 when energized by the square pulse *a*. As indicated in Fig. 2a a plurality of such false echoes may be produced.

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If it be attempted to avoid these false echoes by increasing the resistance of the circuit so that the character of the circuit would be non-oscillatory in accordance with the expression

$$R^2 > \frac{4L}{C}$$

then the energy available for the desired pulse *a* would be greatly decreased, for, since the resistance of the tube during conduction would be low relative to the resistance of the circuit, much of the energy of the impulse would be lost in the resistance of the external circuit.

In order to avoid the weak impulses of the type indicated at *c* and still preserve the character of the desired pulse *a* and maintain this pulse at a high energy level, I provide a device having negative resistance-current characteristics in the discharge circuit of the condenser, as indicated at 16. The nature of the voltage impressed across the tube 1 as a result of the discharge of the condenser, when such a device is employed, may be understood by reference to the curve shown in Fig. 2b. This figure illustrates the general characteristics of the voltage across the tube when such a device is employed and it will be seen that the initial pulse *a* has the same characteristics as the pulse *a* in Fig. 2a. It attains a level at which the tube is efficiently energized to provide strong pulses of ultra high frequency oscillations. During this period the device 16 offers but small resistance to the current flow in the primary circuit since the current therethrough is high. Maximum energy is therefore supplied to the tube 1 and this is in the direction in which the tube is conductive. When the current through the primary winding 8 falls to a low value, as the voltage on the condenser 12 reverses, the resistance of the device 16 becomes great, thus matching the resistance of the tube 1 which offers great resistance as the voltage thereacross drops to a level below which the tube will no longer conduct.

As is well known, a magnetron does not conduct at low voltages, and during the period that the voltage thereacross is rising to such a value and in such a direction that the tube is conductive, its resistance is high. After the tube becomes conductive its resistance is relatively low until the voltage again drops to a value below which it is no longer conductive, at which time the resistance is again high. It will be seen that the device 16 matches these conditions since its resistance is high when the current therethrough is low, and its resistance becomes low when the current therethrough is high. The high resistance of the circuit to the low current thus prevents the sharp reversal of the voltage across the tube 1 so that the reverse voltage indicated at *b* does not rise to the same level as the reverse voltage indicated by the portion of the curve *b* of Fig. 2a. On the contrary the reverse voltage rises gradually and then dies away substantially exponentially since the resistance of the device 16 increases substantially exponentially as the current therethrough decreases. Accordingly, the current does not again reverse and there is no further impulse in the direction in which the tube is conductive, and therefore no false echoes corresponding to the impulse *c* of Fig. 2a are generated.

As previously stated condenser 12 may be charged from a source of either direct or alternating current connected to the terminals 9. In case direct current is used the tube 10 acts as

a blocking tube to prevent pulses of current from being sent back to the power supply line and to hold the voltage on the condenser constant until firing occurs. In case alternating current is used as the power supply source, the tube 10 functions as a rectifying and blocking tube and the spark gap 15 is synchronously driven to fire at a predetermined point in the alternating cycle, preferably when the condenser voltage is at its peak. The peak values of the charging current saturate the choke 11 and thus eliminate variations in the energy impulses supplied to the tube 1 due to variations in firing point of the spark gap.

In either case the values of the inductance 11 and of the capacitance 12 are so correlated to the frequency of the spark gap as to give resonance charging of the condenser in accordance with the expression

$$f = \frac{1}{2\sqrt{LC}}$$

where f is the spark gap frequency, L the inductance of the choke, and C the capacitance of the condenser. By this arrangement the voltage across the spark gap is substantially double the line voltage in the direct current case, and without blocking the tube more than double the line voltage in the alternating current case.

It will be observed that since the voltage across spark gap 15 does not oscillate, the erosion of the sparking points is minimized.

While the invention has been described by means of a specific embodiment, other embodiments within the scope of the appended claims will be obvious to those skilled in the art from a consideration of the embodiment shown and the teachings hereof. It will be understood that while the invention has particular utility at ultra high frequency, it is nevertheless useful in other applications at lower frequency.

What is claimed is:

1. An electrical system including a condenser, means for intermittently charging said condenser a load circuit through which energy from said condenser is intermittently discharged, a space discharge tube for generating oscillations coupled to said circuit and adapted to be energized intermittently from said circuit, and a resistance having negative resistance-current characteristics in said circuit.

2. An electrical system including a condenser, means for intermittently charging said condenser a load circuit through which energy from said condenser is discharged, a space discharge tube energized intermittently from said circuit, and means in said circuit having high impedance when the current therethrough is low, and low impedance when the current therethrough is high.

3. An electrical system including an energy storage device, means for intermittently feeding electrical energy to said device, a load circuit through which energy from said storage device is discharged intermittently, said load circuit including a resistance having negative resistance-current characteristics, and an oscillator coupled to said load circuit and adapted to be energized in synchronism with the discharges of energy through said load circuit.

4. An electrical system adapted to produce pulses of oscillations including a condenser, means for intermittently charging said condenser, a discharge device for generating oscillations, and a circuit coupled to said condenser and to said

device for intermittently energizing said device by energy derived from the intermittent discharge of said condenser, said circuit including a resistance having negative resistance-current characteristics.

5. An electrical system adapted to produce pulses of oscillations including an energy storage device, a space discharge device for generating oscillations, and a circuit for intermittently energizing said space discharge device by energy derived from said energy storage device, said circuit including a resistance having negative non-linear resistance-current characteristics.

6. An electrical system adapted to produce pulses of ultra high frequency oscillations comprising a condenser, a space discharge device for generating ultra-high frequency oscillations, a circuit for intermittently energizing said space discharge device by energy derived from said condenser, means for converting the discharge of said condenser into a substantially rectangular wave form, and means in said circuit for altering the impedance thereof to match the impedance of said space discharge device.

7. An electrical system for producing pulses of ultra-high frequency energy including a condenser, a source of current for charging said condenser, a circuit including a pulse line through which said condenser is discharged, a resistance having negative resistance-current characteristics in series with said pulse line and said condenser, and a magnetron oscillator for generating ultra-high frequency oscillations energized from the discharge circuit of said condenser.

8. An electrical system for producing pulses of ultra-high frequency energy including a condenser, a circuit including a pulse line through which said condenser is charged, a circuit including said pulse line and a resistance having negative resistance - current characteristics through which said condenser is discharged, and a magnetron oscillator for generating ultra-high frequency oscillations energized from the discharge circuit of said condenser.

9. An electrical system for producing pulses of ultra-high frequency energy including a condenser, a pulse line, a transformer in series with said pulse line through which said condenser is charged, a circuit including said pulse line, said transformer and a resistance having negative resistance-current characteristics through which said condenser is discharged, and a magnetron oscillator for generating ultra-high frequency oscillations energized from said transformer.

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Certificate of Correction

Patent No. 2,462,918.

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KARL J. STIEFEL

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 3, line 35, for "comprehented" read *comprehended*; column 4, lines 3 and 4, for "non-iscillatory" read *non-oscillatory*; column 5, line 44, claim 1, and line 53, same column, claim 2, after the word "condenser" insert a comma; line 55, after "is" insert *intermittently*; line 56, same claim, before "energized" insert *coupled to said circuit and adapted to be*;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 28th day of June, A. D. 1949.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.

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[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.