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PULSE GENERATOR

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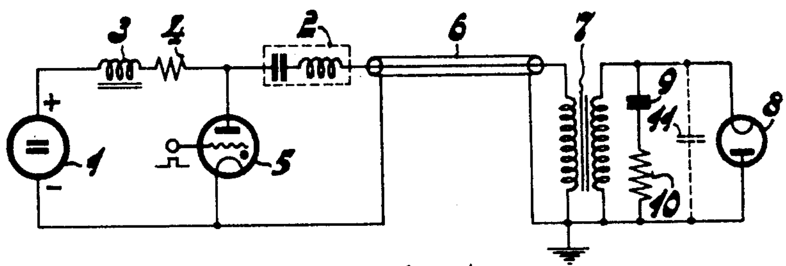

Fig. 1.

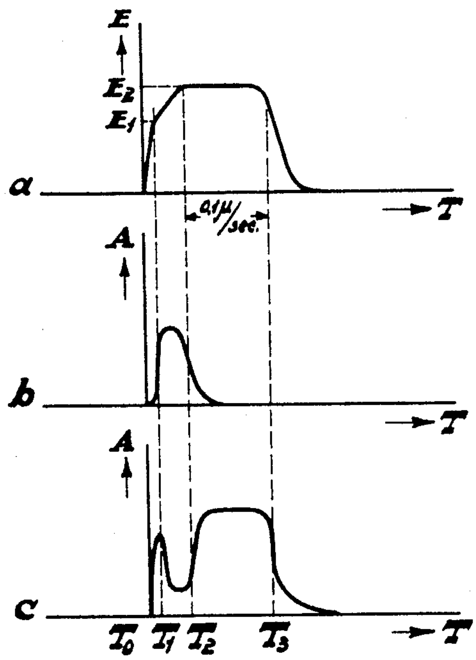

Fig. 2.

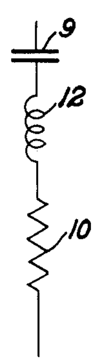

Fig. 3.

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PULSE GENERATOR

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6 Claims. (Cl. 250—36)

This invention relates to circuit-arrangements comprising a magnetron which is energised by impulses, for example radar apparatus, in which the magnetron is connected via an impulse transformer to an artificial line supplying the energisation impulses.

The invention may be used with particular advantage in producing carrier-wave impulses having a high peak power, for example of several times ten kw. or more and a short impulse duration, for example 1 μ sec. or less. In such circuit-arrangements the artificial line is first charged to a high direct voltage and then the artificial line is discharged via the magnetron by means of a switch consisting of an electron-discharge tube, a gas-filled tube or a spark gap, the impulse transformer provided between the magnetron and the artificial line serving interalia for impedance-matching.

In several types of magnetron tubes, means should be provided for limiting the steepness of the flank of the energising pulses in order to prevent a given limit of said steepness of the flank of the energisation pulses from being surpassed. For example, with magnetrons of the Philips type 4J50 the maximum permissible steepness of the leading edges of the energising pulses is 110 kv. μ sec. Especially in designing magnetron generators for high peak powers and a particularly short impulse duration, for example 0.1 to 0.25 μ sec., particular attention must be given to this condition.

Prior patent application U. S. Serial No. 360,876, filed June 11, 1953, describes a suitable and simple circuit-arrangement for limiting the flank-steepness of energisation pulses of short duration and high peak power, the energisation pulses supplied by the artificial line being fed to the magnetron via the parallel-connection of a resistor and a coil, which coil comprises a ferro-magnetic core which becomes saturated during the occurrence of the energisation pulses. In this circuit-arrangement, the ferro-magnetic coil core has not yet become saturated on the occurrence of an impulse and the magnetron capacitance is slowly charged via the parallel-connection of the resistor and the coil with the result that the voltage across the magnetron increases gradually. Said saturation does not occur before attaining substantially the energisation voltage of the magnetron, the artificial line subsequently bringing about a strong current impulse through the magnetron.

The present invention has for its object an improved arrangement of the type referred to in the preamble, which comprises means for limiting the flank-steepness of the energisation pulses and may also be used with pulse generators having a connecting cable of considerable length, for example 30 meters, being provided between the impulse transformer and the artificial line.

According to the invention said means comprises the series-connection of a capacitor and a voltage-dependent resistor whose value decreases with increasing voltage, said series-connection being provided in parallel with a winding of the impulse transformer.

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An inductance is preferably connected in series with the capacitor and the voltage-dependent resistor.

Fig. 1 shows a circuit-arrangement according to the invention, comprising a magnetron to be energised by impulses,

Figs. 2a to 2c show time diagrams for explaining the operation of a circuit-arrangement shown in Fig. 1, and

Fig. 3 shows an alternative arrangement of a part of the circuit.

Fig. 1 shows a device according to the invention which comprises a direct current source **1** connected via a choke coil **3** and a resistor **4** to an artificial line **2** for charging it. Connected between the junction point of the resistor 4 and the artificial line **2** on the one hand and the grounded end of the direct current source **1** on the other hand is a normally cut-off, grid-controlled gas-discharge tube **5** which is made conductive by control impulses supplied to its grid. The primary winding of an impulse transformer **7**, whose secondary winding is connected in parallel with a magnetron **8** constituting the load, is connected to the artificial line **2** via a connecting line **6** with grounded outer envelope. Each time a control impulse appears at the control grid of the gas-discharge tube **5**, the artificial line **2** becomes discharged through the primary winding of the transformer **7** and supplies an energisation impulse for the magnetron which then supplies a carrier-wave impulse of, say, approximately 0.1 μ sec. of high power. The secondary winding of the transformer **7** may, as customary, be bifilar in conjunction with the supply of heating current for the cathode of the magnetron.

In order to protect the magnetron the circuit-arrangement described comprises means for limiting the flank-steepness of the energisation impulses. According to the invention said means comprises the series-connection of a capacitor **9** and a voltage-dependent resistor **10** whose value of resistance decreases with increasing voltage, said series-connection being provided in parallel with the secondary winding of the impulse transformer **7**.

The voltage-dependent resistor may, for example, mainly consist of silicon carbide and filling material.

Naturally other types of these resistors may alternatively be employed.

The operation of the circuit-arrangement described, will now be explained more fully with reference to the time diagrams shown in Fig. 2. Fig. 2a represents the voltage across the secondary terminals of the impulse transformer **7**, and Figures 2b and 2c represents the current taken up by the network **9**, **10** and the current to the magnetron respectively.

Let it be assumed that the tube **5** acting as a switch has been made conductive by a control impulse, thus permitting the artificial line **2**, which has been charged to a high direct voltage, to become discharged via the connecting line **6**, the impulse transformer **7** and said tube **5**. At the beginning of an impulse at the impulse transformer **7** at the instant T_0, the voltage-dependent resistor **10** has a comparatively high value, the load of the impulse generator then mainly consisting of the parallel-capacitance **11** of the magnetron **8**, which capacitance is shown in broken lines in Fig. 1.

After the production of an energisation impulse, the capacitance **11** becomes rapidly charged, and the voltage across the magnetron **8** and the network **9**, **10** rises rapidly to a value E_1 which is attained at the instant T_1, as shown in Fig. 2a. The current of T_0 to T_1, as shown in Fig. 2c, is the charging current of the magnetron capacitance **11**.

At the instant T_1 the value of the voltage-dependent resistor **10** has dropped to such a degree that the capacitor **9** of the network **9**, **10** also draws a considerable current. The current taken up by the network **9**, **10** is indicated in Fig. 2*b*, Fig. 2*c* showing that the charging current of the magnetron capacitance **11** decreases during the time interval T_1 to T_2.

Owing to the decrease in value of the resistor **10**, the voltage of the magnetron **8** after the instant T_1 increases less rapidly than before, as shown in Fig. 2*a*. The rate of the voltage increase at the magnetron **8** from the instant T_1 onwards until attaining the energisation voltage E_2 at the instant T_2 is adjustable at will by a suitable proportioning of the network **9**, **10**.

As soon as the energisation voltage E_2 of the magnetron is attained, the magnetron draws a strong current impulse and supplies a carrier-wave impulse of, say 0.1 μ sec. during the interval T_2 to T_3. During this time interval the network **9**, **10** does not take up appreciable energy.

When the energisation of the magnetron **8** is terminated at the instant T_3, the voltage of the magnetron drops to zero but comparatively slowly owing to the presence of the network **9**, **10**. The tube **5** extinguishes automatically when its anode voltage reaches a sufficiently low value when the line **2** has almost completely discharged, and thus the grid regains control of the tube. The artificial line **2** is subsequently again charged by the direct current source **1** and the cycle described is repeated on the occurrence of a next control impulse at the control grid of the tube **5** acting as a switch.

The network **9**, **10** instead of being connected in parallel with the secondary of the impulse transformer **7** may be connected in parallel with the primary, but in the last-mentioned case it is found to be more difficult to obtain the desired shape of the flank.

In practice, it has been found that when using the network **9**, **10** in parallel with a transformer winding, undesirable reflection phenomena are reduced to an extremely high degree. In this respect it is advantageous that the building-up time of the leading edge of the energisation pulses is particularly short.

In a particularly suitable alternative embodiment of the device described, a self-inductance **12** (Fig. 3) is connected in series with the capacitor **9** and the voltage-dependent resistor **10**. This measure yields the advantage that the loss of energy in the voltage-dependent resistor **10** is reduced, since, in order to obtain the desired form of the leading edge of the energisation pulses, a smaller voltage-dependent resistor may now be employed.

What is claimed is:

1. A circuit-arrangement comprising a pulse-operated device, a source of electrical pulses connected in parallel with said device, and a series combination of a capacitor and a voltage-dependent resistor the resistance of which decreases with an increase in applied voltage, said combination being connected in parallel with said device and said source of pulses.

2. A circuit-arrangement as claimed in claim 1, including a self-inductance member connected in series with said series combination.

3. A circuit-arrangement comprising a pulse-operated device, a source of electrical pulses, a transformer having a primary winding connected in parallel with said source and a secondary winding connected in parallel with said device, and a series combination of a capacitor and a voltage-dependent resistor the resistance of which decreases with an increase in applied voltage, said series combination being connected in parallel with one of said windings.

4. A circuit-arrangement as claimed in claim 3, in which said series combination is connected in parallel with said primary winding.

5. A circuit-arrangement as claimed in claim 3, in which said series combination is connected in parallel with said secondary winding.

6. A circuit-arrangement comprising a source of direct voltage, a two-terminal artificial line, current-conductive means connected between a terminal of said voltage source and a first terminal of said line, a transformer having a primary winding connected between the remaining terminal of said line and the remaining terminal of said voltage source and having a secondary winding, a switch device connected between said first terminal and said remaining terminal of the voltage source, means connected to periodically operate said switch device to discharge said line, a magnetron connected in parallel with said secondary winding, and a series combination of a capacitor and a voltage-dependent resistor the resistance of which decreases with an increase in applied voltage, said series combination being connected in parallel with said secondary winding and said magnetron.

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