

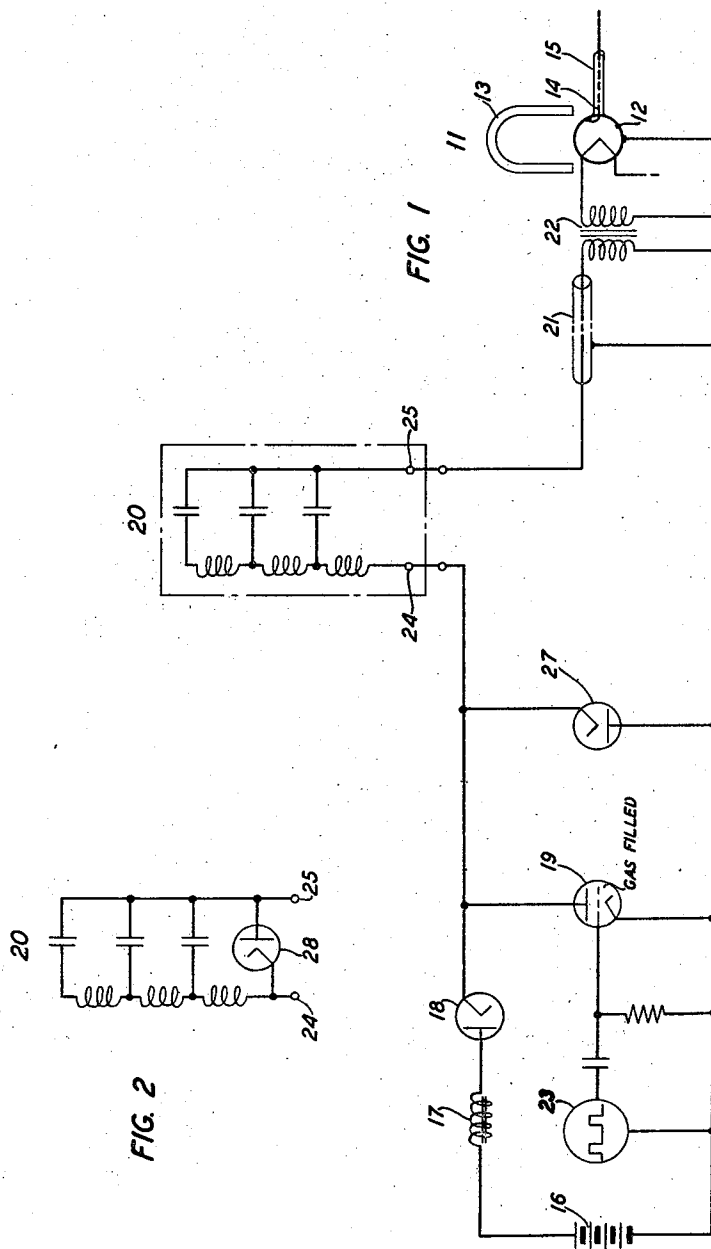
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PULSER CIRCUIT

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PULSER CIRCUIT

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1

This invention relates to pulse generators particularly those for generating recurrent pulses of ultra-high frequency radio waves, and has for an object to improve the operation of such system and especially to prevent failure due to the production of excessive voltages.

In object-locating and other types of systems it is desirable to transmit recurrent short pulses of radio waves of high energy. In the case of object-locating systems in particular, it is desirable that the pulses of radio oscillations should have a substantially rectangular envelope wave form. Such a characteristic is conveniently obtained by energizing the anode circuit of a high frequency oscillation generator by direct-current pulses of corresponding rectangular wave form. One method of forming such direct-current pulses is by the use of pulse-forming networks in the form of open-circuit artificial lines or equivalent two-terminal networks. If such a line network is charged to a high voltage and a load equal to its characteristic impedance is suddenly connected thereto, the voltage applied to the load will assume a value equal to one-half the voltage to which the line was charged and will be maintained at that value for twice the transmission time of the line, when it will suddenly drop to zero.

By the use of such pulse-forming networks together with an inductive charging circuit that permits charging the network to approximately twice the voltage of a direct-current source and a cyclically operated switching device, very effective pulsing circuits for ultra-high frequency oscillators have been built. In such a circuit it has been found that "Thyratron" or grid-controlled gas discharge tube has certain advantages for use as the switching device. When using such a system it was found that if for any cause the oscillator tube arced, as occurs occasionally particularly during the latter portion of the life of a tube, such action was very likely to be repeated during subsequent pulses with the accompanying phenomenon of an increasing voltage in the circuit until a final breakdown occurred.

A further object of the invention is to prevent the building-up of such excessive voltages in pulsing systems of the type described above.

In the operation of a pulsing circuit as briefly described above the pulse-shaping network of the line type is charged from a direct-current source through an inductor to substantially twice the direct-current voltage during the period of each cycle in which the "Thyratron" is non-conducting. When the "Thyratron" is triggered the effect is

2

to connect the high frequency oscillator space path, having an impedance equal to the characteristic impedance of the network, across the network. The effect of this is to impress a voltage equal to one-half the charged voltage of the network on the oscillator space path and simultaneously to send a voltage pulse also equal to half the charge voltage, down the line. This voltage pulse will be reflected at the far, open-circuited end of the line and return to the near end terminals where it will oppose the voltage across the load and extinguish the current there-through. Since the oscillator and line impedances are matched, both charges will be extinguished and there will be no further reflections. The result is that the oscillator will have impressed thereon a pulse equal to half the voltage of the original charge on the line and lasting for a time equal to twice the transmission time of the line. (When an equivalent two-terminal network is used in place of a line network a similar explanation can be given in terms of resonant effects rather than transmission time.)

Applicant's solution of the problem of the production of excessive voltages, referred to above, was only achieved after a careful analysis of the cause of the phenomenon. He discovered that when an arc occurred in the oscillator tube the line network was no longer terminated in a load impedance equal to its characteristic impedance but rather in a lower impedance. Accordingly, the charge voltage on the line does not divide equally between the load and the line, but instead the line voltage assumes a value higher than that of the load. Accordingly, the reflected voltage returning to the network input terminals is greater than that required to extinguish the load voltage and would tend to produce a reverse current through the load. However, the "Thyratron" connecting the network to the load conducts in only one direction and so prevents the establishment of such a current and the resultant dissipation of the charge. Instead, the network retains a charge of opposite polarity to its normal charge. As a result of this reverse polarity charge and of the resonant charging characteristic, the network is charged to a voltage higher than normal during the following period.

As a consequence the oscillator space path will have impressed thereon a higher-than-normal voltage during the succeeding pulse period and since it arced previously due to a normal voltage it will be almost sure to arc under the influence

of this larger voltage. Further, since the excess of charging voltage accumulated by the network during each resonant charging period is dependent upon the value of the initial reverse charge, this effect will be cumulative from pulse to pulse.

In accordance with a feature of this invention such effects are prevented by providing a path for discharging any reverse polarity voltages in the network. In particular, a diode is connected in shunt to the "Thyratron" space path to provide a conducting path in the opposite direction to that provided by the "Thyratron," or alternatively a diode is connected across the terminals of network to provide a path for discharging any reverse polarity charges.

These and other objects, features and aspects of this invention may be better understood by reference to the following detailed description in connection with the drawing in which:

Fig. 1 is a schematic circuit diagram of one embodiment of the invention; and

Fig. 2 is a modification of a portion of the circuit of Fig. 1.

The system of Fig. 1 produces recurrent short pulses of high power ultra-high frequency radio waves. The ultra-high frequency oscillations are generated in a multicavity magnetron 11 which may be of the type of United States Patent 2,063,342 to Samuel, December 8, 1936, for example. In this type of ultra-high frequency oscillator the anode 12 forms the external sheath or enclosure which it is desirable to maintain at ground potential. When this is subjected to a magnetic field supplied by the permanent magnet 13 and a high direct-current voltage is impressed between the anode and cathode there are produced high power oscillations of frequency determined by the internal structure of the device as described in more detail in the Samuel patent referred to. These oscillations are picked up by a loop 14 and transmitted through a coaxial line 15 to an antenna or other utilization circuit (not shown).

The present invention is primarily concerned with the remainder of the circuit which provides the high-voltage pulses that are impressed between the anode and cathode of this magnetron 11.

The prime source is a battery 16, though of course it may be a rectifier, generator or other direct-current source. A charging inductor 17 and a charging diode 18 provide a circuit for charging the pulse-shaping, line network 20. A coaxial cable 21 provides a circuit for supplying the pulse to the magnetron 11 since in the usual installation the magnetron is located at some distance from the pulser. At the magnetron a pulse transformer 22 provides a means for impressing the pulse on the anode-cathode circuit of the magnetron. The transformer 22 also steps up the voltage of the pulse transmitted over the line 21 since for economical design the coaxial line 21 is operated at a somewhat lower voltage than required for the magnetron.

The transformer 22 also provides a two-way conducting path permitting the flow of current in one direction for charging the network 20 and in the opposite direction when the network is discharged to the magnetron. In other applications where the magnetron is located in the vicinity of the pulser and a transformer is not used, a diode may be connected in shunt to the magnetron for providing a path in the opposite

direction to that provided by the magnetron to permit the flow of charging current.

A "Thyratron" or gas discharge tube of the triode type 19 is provided for discharging the network 20 in the form of a pulse to the magnetron 11 to cause its oscillation. The tube 19 is controlled by triggering pulses supplied to its grid from the source 23.

In the normal operation of the system during the period when the tube 19 is non-conducting (no triggering pulse being applied to its grid) the network 20 which acts as a capacity during this portion of the cycle will charge to a voltage substantially twice the voltage of the battery 16 due to the effect of the inductor 17. The diode 18 prevents the reversal of this charging current which would normally occur in such a resonant charging circuit, permitting the network voltage to assume a voltage equal to the battery voltage after the decay of the charging transient. At some instant after the network 20 has assumed its full charge, the tube 19 will be rendered conductive by the positive triggering voltage applied to its grid from the timing source 23. This forms a path for the discharge of the network 20 to the magnetron 11.

The circuit is designed so that load presented to the network 20, comprising the coaxial cable 21 terminated in the transformer 22 and the space path of the magnetron 11, is substantially equal to the characteristic impedance of the network 20. As a result the current flow in the discharge circuit will cause the network voltage to be divided equally between the terminals 24-25 of the network and the load circuit. Simultaneously a disturbance will travel down the network, be reflected at the distant open circuited end and return to the terminals 24-25. During this period (twice the transmission time of the network) the voltage across the load and consequently the magnetron will be maintained at its original value. The voltage disturbance returning to the terminals 24-25 will reduce the voltage across the network and the load to zero and extinguish the tube 19.

The network 20 will then begin to charge again and the cycle will be repeated.

As was discussed in some detail previously difficulty is sometimes encountered due to arcing in the space path of the magnetron. Such action has been found to take place occasionally in particular in systems in which the magnetron is worked close to its limit and especially during the latter portion of the life of the tube. An occasional arc is not particularly troublesome as it only means the omission of one of a long series of recurrent pulses. However it was found that with the particular type of pulsing system described, arcs did not occur singly but almost always were repeated from pulse to pulse with an increasing voltage. Applicant discovered that this phenomenon was due to the fact that the mismatch of impedance between the network and the load caused by the reduction of the load impedance by the arc resulted in a residual voltage charge of opposite polarity on the network. This charge could not be dissipated because the tube 19 conducted in only one direction, namely for the discharge of a charge of normal polarity, and presented a very high impedance for charges of the opposite polarity. As a result of the characteristic of the resonant charging circuit the effect of such a reverse polarity residual charge was to raise the voltage to which the network was charged during the next charging period,

5

Obviously this effect would be cumulative from cycle to cycle.

In order to overcome such effects a diode tube 27 is connected in parallel to the space path of the tube 19 with its cathode connected to the anode of the tube 19 and its anode connected to the cathode of the tube 19. Accordingly the diode 27 provides a conduction path in the direction opposite to that provided by the tube 19. Thus, any reverse charge in the network 20 will find a low impedance path through the diode 27 and will be quickly dissipated. On the other hand the impedance of the diode 27 in the reverse direction in which the tube 19 conducts when triggered is very high so that it does not interfere with the normal operation of the system.

Fig. 2 shows a modification of the circuit arrangement of Fig. 1 in which a diode 28 is connected directly across the terminals 24—25 of the network 20 in such a direction as to present a high impedance to voltages of the polarity supplied by the charging current from the battery 16 but a low impedance to voltages of the opposite polarity. This circuit arrangement was found to prevent the accumulation of any reverse polarity voltages on the network and so prevent the difficulties due to development of excess voltages even when the diode 27 was omitted from the circuit.

What is claimed is:

1. In a pulse generating system, a reflecting line type pulsing network for storing electrical energy and proportioned to provide a pulse of uniform amplitude and preassigned duration, an inductor forming with said network a resonant charging circuit, a load circuit, a switching device having a unidirectional conducting characteristic for discharging said network to said load and a unilateral conducting device connected in shunt to said switching device to provide a conducting path in the direction opposite to that provided by said switching device.

2. An ultra-high frequency pulse transmitter comprising a space discharge oscillator, a source of electrical energy, and a circuit for supplying pulses of space current to said oscillator, including a reflecting line type storage and pulse-forming network, an inductor connecting said source to said network and forming with said network

6

a resonant charging circuit, a grid-controlled gas discharge tube connected to discharge said network to said oscillator, means for triggering said tube, and a unilateral conducting device connected to prevent the accumulation of charges on said network of polarity opposite to that supplied by said resonant charging circuit.

3. An ultra-high frequency pulse transmitter comprising a space discharge oscillator, a source of electrical energy, and a circuit for supplying pulses of space current to said oscillator, including a reflecting line type storage and pulse-forming network, an inductor connecting said source to said network and forming with said network a resonant charging circuit, a grid-controlled gas discharge tube connected to discharge said network to said oscillator, means for triggering said tube, and a unilateral conducting device connected in shunt to said tube to form a conducting path in the direction opposite to that provided by said tube to prevent the accumulation of reverse polarity charges on said network.

4. An ultra-high frequency pulse transmitter comprising a space discharge oscillator, a source of electrical energy, and a circuit for supplying pulses of space current to said oscillator, including a reflecting line type storage and pulse-forming network, an inductor connecting said source to said network and forming with said network a resonant charging circuit, a grid-controlled gas discharge tube connected to discharge said network to said oscillator, means for triggering said tube, and a unilateral conducting device connected in shunt to said network to provide a low impedance path for the discharge of charges of polarity opposite to that supplied by said source.

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