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PULSED OSCILLATOR

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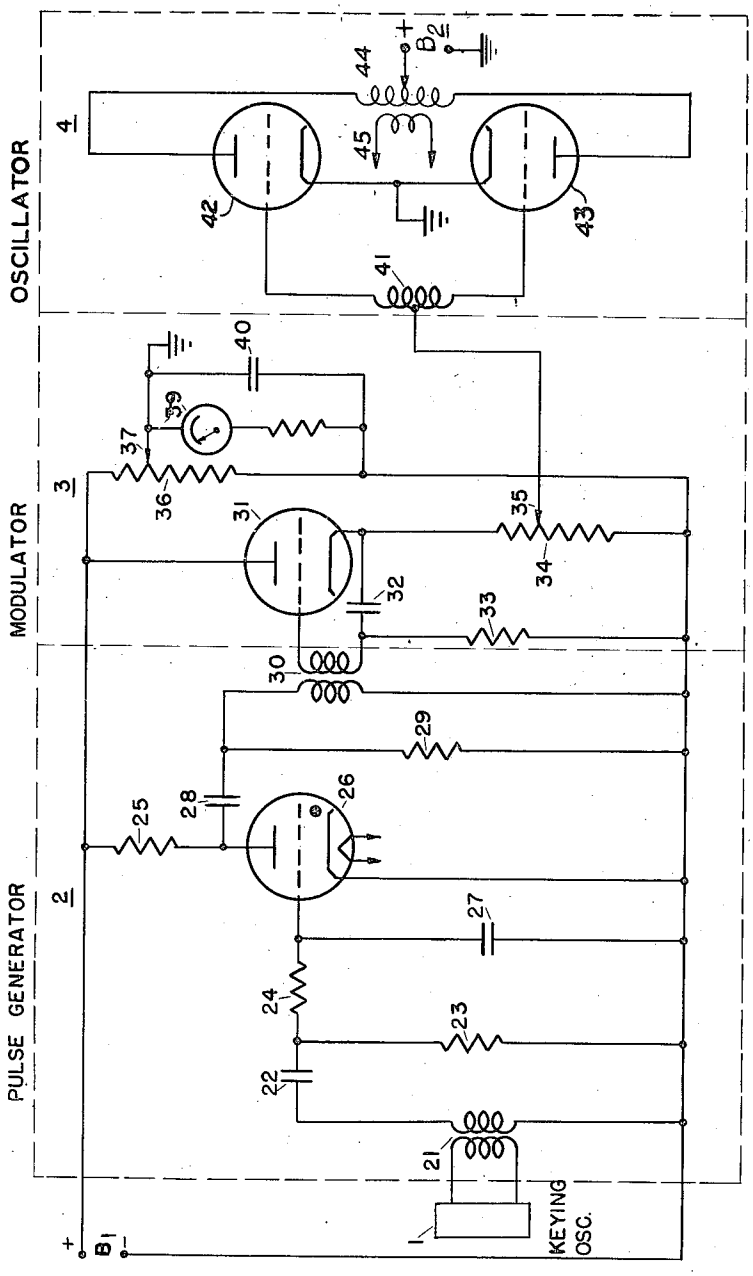


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## PULSED OSCILLATOR

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8 Claims. (Cl. 250—36)

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The invention described herein may be manufactured and used by or for the Government for governmental purposes, without payment to me of any royalty thereon.

This invention relates to radio transmitters, especially such as are used in pulse-echo systems of object detection. It is necessary in such systems to make the pulses as sharp as possible in order to avoid confusion between the transmitted pulses and the pulses reflected from objects a relatively short distance away. Sharp pulses also permit use of large peak powers and at the same time keep the average power at a relatively low level.

It is therefore an object of this invention to devise a radio frequency transmitting system which can be used for emitting very sharp pulses of radio frequency energy.

It is a further object of this invention to devise an improved method of pulse modulating a transmitter of radio frequency waves.

It is a further object of this invention to provide a novel electron tube circuit for pulse modulating the transmitter of a pulse-echo system, in which both transmitter and modulator are normally biased near cut-off, whereby power is dissipated by both transmitter and modulator tubes only during pulse transmission, thereby increasing the life of the tubes and/or their pulse-power handling capacity.

Further objects will be apparent from the following specification and the drawing.

The single figure in the drawing is a schematic circuit illustrating the invention.

With reference to said drawing a keying oscillator 1 of relatively low frequency is coupled to a pulse generator 2 through a transformer 21. One terminal of the secondary is connected to the grid of a gas tube 26 through a high capacity blocking condenser 22 and a resistor 24 of about 25,000 ohms. Tube 26 is a grid controlled tube of the arc discharge type, one type of which is commonly known as a "Thyratron." A resistor 23 having a value of about one megohm is connected between the junction of condenser 22 and resistor 24 and the low potential side of the secondary.

The cathode of the tube 26 is connected to the low potential side of the secondary coil and to the negative pole of the plate power source B1. A condenser 27, having a capacity of about 25 micro-microfarads, is connected between the grid and cathode of said tube.

The plate of tube 26 is connected to the positive pole of the plate potential source B1 through a resistor 25 of the order of 400,000 ohms. Also connected between the plate and cathode are a condenser 28 and resistor 29 in series. Resistor 29 is of the order of 1,000 ohms.

Across the resistor 29 is connected the primary

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of a transformer 30 the secondary of which is connected to the input circuit of a modulator circuit, either directly or, if necessary, through one or more amplifiers.

The high potential terminal of the secondary is connected directly to the grid of a tube 31. The other terminal of the secondary is connected to the cathode of tube 31 through a one microfarad condenser 32. The latter terminal is also connected to the negative pole of source B1 through a resistor 33 which may have a value of from 50,000 to 100,000 ohms. The cathode of tube 31 is also connected to said negative pole through a 10,000 ohm potentiometer resistor 34.

Across the source B1 is connected a potentiometer 36 of about 75,000 to 150,000 ohms. Sliders 35 and 37 of the potentiometers constitute the output terminals of the modulator. Slider 37 is grounded and connected to the negative pole of source B1 through a condenser 40 of about two microfarads. A meter 39 is connected across the portion of potentiometer 36 between slider 37 and the negative pole of source B1 to measure the voltage therebetween.

The output lead from slider 35 is connected to the center tap of the oscillator coil 41 the ends of which are connected to the grids of oscillator tubes 42 and 43. The cathodes of said tubes are grounded. The anodes are connected to opposite ends of coil 44. The center tap of said coil 44 is connected to the positive pole of a separate source of plate potential B2, the negative pole of which is grounded. Condenser 40 serves as a smoothing filter for source B1 and as a radio frequency bypass condenser.

Coils 41 and 44, together with the distributed capacity and interelectrode capacities thereacross, form the resonating tank circuits for the plates and grids of radio frequency oscillating tubes 42 and 43 connected for push-pull operation. Feedback, between the plate and grid circuits to maintain oscillation, is produced by electromagnetic coupling between the plate and grid coils or by means of the interelectrode capacitances, or by both expedients. The radio frequency output of the oscillator is fed, by means of a coil 45 coupled to coil 44, to an antenna either directly or through a series of power amplifiers.

The above-described system operates as follows:

When the voltage applied from keying oscillator 1 to the grid of gas tube 26 is negative, the other parameters are such that said tube is non-conducting. Condenser 28 acquires a charge from voltage source B1 through resistor 25. When its grid becomes positive, the tube 26 becomes conducting and the condenser 28 suddenly discharges through the primary of transformer 30 and the anode-cathode path of tube 26. Since the capacity of condenser 28 is low and the resistance

of resistor 29 and coil 30 are small, the time of said discharge is very short and a sharp pulse is impressed upon transformer 30 and in turn is impressed, either directly or after further amplification, upon the grid of modulator tube 31.

After condenser 28 is completely discharged, tube 26 becomes non-conducting because resistor 25 drops the plate voltage below the operating level of the tube. As a result the grid again regains control until the next positive alternation from keying oscillator 1. Thus a pulse is generated at every cycle of current from the oscillator. The successive pulses are preferably of considerably shorter duration than the intervals therebetween.

Resistor 24 limits the amount of grid current flowing through the gas tube so as not to unduly load oscillator 1. Condenser 27 by-passes all stray radio frequency currents from oscillator 4 due to imperfect shielding, shock-excitation, etc.

The output of the pulse generator is applied to the grid of modulator tube 31 and to the cathode through condenser 32, which should be of such size as to offer substantially no impedance to the pulse energy. Said tube is operated near cut-off due to the high resistance of load resistor 35. When the grid of the tube is driven positive by the pulse, a steep surge of current will flow through cathode resistor 35, the phase of this voltage being identical with that of the grid voltage. The values of condenser 32 and resistor 33 are such as to prevent degenerative effects in the grid-cathode circuit. The time constant of the latter network is such, however, as to assure bias to near cut-off during intervals between pulses. Thus, although the load is in the cathode circuit as in a cathode follower, it does not, like the latter, have any degenerative effect on the signal.

The tube 31 and resistors 34 and 36 form, in effect, a bridge circuit with the plate voltage impressed upon two of the conjugate points and sliders 35 and 37 constituting output leads at the other two conjugate points. The voltage at the output points is impressed as biasing potential on the oscillator.

The amount of grid bias impressed on the grids of oscillator tubes 42 and 43 is equal to the voltage drop in resistor 34 below tap 35 minus the voltage drop in resistor 36 below tap 37. In the absence of a pulse on the grid of tube 31 the voltage drop in resistor 34 is negligible and the bias on the oscillator grids is highly negative, depending upon the position of slider 37, whereby the oscillator tubes are cut off and no radio frequency oscillations are generated. Meter 39 indicates the voltage of the negative grid bias.

When a positive pulse on its grid renders tube 31 conductive, the voltage drop across resistor 35 reduces the amount of negative bias on the grid or renders it slightly positive to such an extent that tubes 42 and 43 are permitted to oscillate for the duration of the pulse.

In the case where the oscillator grids are driven positive, considerable power may be absorbed in the grid circuits and the modulator tube must be capable of delivering such power. With the above modulator circuit such power is only drawn for the duration of the pulse. Hence, although the peak power developed both in the modulator and oscillator may be large, the average power which the tubes must handle is relatively small.

Although a gas tube pulse generator circuit is shown, it should be understood that any other type of pulse generator may be used. Other modifications may be made without departing from the spirit of the invention as defined in the appended claims.



I claim:

1. A radio frequency pulse transmitting system comprising a source of spaced energy waves of relatively low frequency, the duration of said waves being a small fraction of the interval therebetween, a non-degenerative vacuum tube power amplifier circuit normally biased substantially at cut-off coupled to said source, a plate potential source having its positive terminal connected to the anode of said tube, a load circuit connected between the negative terminal of said plate potential source and the cathode of said tube, a radio-frequency power circuit having a tube with insufficient potential impressed thereon to sustain oscillations, and a circuit for impressing the output of said load circuit upon said last-mentioned tube in such manner as to increase said potential sufficiently to render said radio frequency circuit operative for the duration of said waves.

2. A radio frequency pulse transmitting system comprising a source of relatively low frequency alternating voltage, a pulse generator keyed by said source in such manner that a sharp pulse is generated at every cycle of said voltage, the duration of said pulse being a small fraction of the duration of said cycle, a non-degenerative vacuum tube power amplifier circuit, normally biased near cut-off, coupled to said pulse generator, a source of plate potential having its positive terminal connected to the anode of said tube, a load circuit connected between the negative terminal of said plate potential source and the cathode of said tube, a radio-frequency power oscillator circuit having a tube with its grid circuit normally biased negatively to cutoff, and a circuit for impressing the pulse output of said load circuit upon said grid circuit and render it positive, whereby said oscillator circuit will oscillate for the duration of said pulse.

3. In a pulse transmitting system, a radio frequency network including a vacuum tube, a source of voltage connected to said tube to render it inoperative, a modulating circuit for said network comprising an electron tube having an anode, cathode, and grid, said anode being connected to the positive pole of a direct current power source, a load circuit connected between said cathode and the negative terminal of said power source, a source of spaced pulses connected between said grid and the junction of said cathode and load circuit, a delay network between said load circuit and said grid, the time constant of said delay network being larger than the duration of said pulses, the impedance of said load circuit being such that the voltage impressed therefrom upon said grid biases said electron tube near cut-off between pulses, and a circuit for impressing the pulse output of said load circuit upon said vacuum tube in such direction as to oppose said first mentioned voltage sufficiently to render said radio frequency network operative.

4. In a pulse transmitting system, a radio frequency transmitter comprising a grid-controlled vacuum tube and exciting circuits therefor, a source of cut-off bias voltage connected to the grid of said vacuum tube, means to intermittently remove said cut-off bias comprising an electron tube having an anode, cathode, and grid, said anode being connected to the positive pole of a direct current power source, a load circuit connected between said cathode and the negative terminal of said power source, a source of

spaced pulses connected between the grid of said electron tube and the junction of said cathode and load resistor, a delay network between said load circuit and the grid of said electron tube, the impedance of said load circuit and the output polarity and the time constant of said delay network being such that said electron tube grid is biased substantially to cut-off by the potential across said load circuit only during the intervals between pulses, and means for impressing the pulse output of said load circuit upon the grid of said vacuum tube in such direction as to oppose the cut-off bias thereon sufficiently to permit said transmitter to function.

5. In a pulse transmitting system, a radio frequency network comprising a grid-controlled vacuum tube and exciting circuits therefor, a source of voltage connected to the grid of said tube in such direction as to bias it to cut-off, a modulating network for said vacuum tube comprising a second tube having an anode, cathode, and grid, said anode being connected to the positive pole of a direct current power source, a load resistor connected between said cathode and the negative terminal of said power source, a source of spaced positive pulses connected between the grid of said second tube and the junction of said load resistor and cathode, a resistance capacity network between said load resistor and said last mentioned grid, the resistance of said load resistor and the output polarity and the time constant of said last mentioned network being such that the grid of said second tube is biased to cut-off by the potential across said load resistor only during the intervals between pulses, and a circuit for impressing the pulse output of said load resistor on the grid of said vacuum tube in such direction as to oppose the cut-off bias thereon sufficiently to permit said radio frequency network to function for the duration of each pulse.

6. A radio frequency transmitting system comprising a radio frequency oscillating circuit including a grid-controlled electron tube having a grounded cathode, a modulating network for said system comprising a second tube having an anode, cathode, and grid, said anode being directly connected to the positive pole of a source of direct current and a cathode connected to one end of a load resistance, the other end of said load resistance being connected to the negative pole of said source, an input circuit for said network, means to impress sharp spaced pulses on said circuit, the duration of said pulses being less than the intervals therebetween, one end of said input circuit being connected to the grid of said second tube, the other end being connected to one terminal of a condenser having low impedance to said pulses, the other terminal of said condenser being connected to the junction of said cathode and load resistance, biasing means including the potential across said load resistor to bias said second tube near cutoff, said biasing means comprising a second resistance connected between said other end of said load resistance and said other terminal of said input circuit, said condenser and resistances forming a delay network the time constant of which is greater than the duration of each pulse, but less than each interval, a third resistance connected across said direct current source, a movable, grounded contact on said third resistance, and a circuit for impressing the potential at said junction of the cathode and load resistor on the grid of said electron tube.



7. A non-oscillating bridge network for translating spaced pulses generated externally thereof, each of said pulses having a duration which is shorter than the intervals therebetween, said network comprising a tube having an anode circuit connected to the positive pole of a source of direct current and a cathode connected to one end of a load resistance, the other end of said load resistance being connected to the negative pole of said source, an input circuit for said pulses connected to said grid and the junction of said cathode circuit and load resistance, a delay network for impressing the output of said load resistance upon said grid, said load resistance being of such magnitude that the potential thereacross normally biases said tube in the vincity of cutoff, the time constant of said delay network being greater than the duration of said pulses, a second resistance connected across said source, a movable contact on said second resistance, said contact and the junction of said cathode circuit and load resistance constituting the output terminals of said network.

8. A non-oscillating bridge network for translating spaced pulses generated externally thereof, each of said pulses having a duration which is considerably shorter than the intervals therebetween, said network comprising an electron tube having an anode directly connected to the positive pole of a source of direct current and a cathode connected to one end of a load resistance, the other end of said load resistance being connected to the negative pole of said source, an input circuit for said pulses, one end of said input circuit being connected to grid of said tube, the other end being connected to one terminal of a condenser having low impedance to said pulses, the other terminal of said condenser being connected to the junction of said cathode and load resistance, a second resistance connected between said other end of said load resistance and said other terminal of said input circuit, said condenser and resistances forming a delay network the time constant of which is greater than the duration of said signal pulses, said load resistance being of such value that the potential thereacross biases said tube substantially to cut-off during said intervals, a third resistance connected across said direct current source, and movable contacts on said first and third resistances, said contacts constituting the output terminals of said network.

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