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HIGH-INTENSITY PULSING CIRCUITS

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Fig. 1.

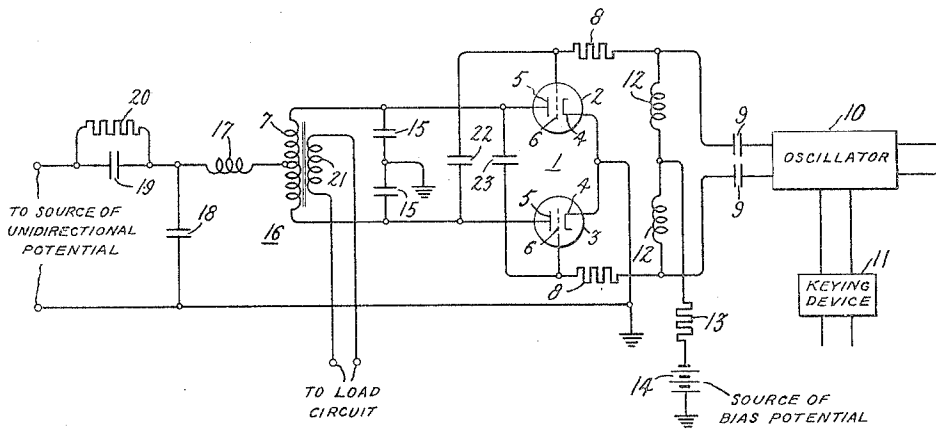
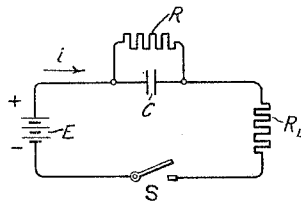


Fig. 2.



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HIGH-INTENSITY PULSING CIRCUITS

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2 Claims. (Cl. 250-27)

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My invention relates to pulsing systems, particularly to transmitting systems for the production of high intensity radio frequency pulses, and its object is to provide an improved system of this character comprising a transmitter arrangement capable of relatively high peak power output.

In accordance with the present invention this object is attained, in a system including for example an amplifier of a given maximum continuous power output capability and having an anode circuit connected to a source of relatively extremely high voltage and a control electrode circuit energized from a keyed oscillator, by the provision of a resistor-capacitor circuit means associated with the anode circuit of the amplifier which permits the peak power output in a load or utilization circuit of the system to be relatively high during a series of pulses produced by normal keying of the amplifier but which limits the amplifier to the above-mentioned maximum continuous power output if the keying device is held continuously closed longer than a predetermined time interval.

The novel features which are considered to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying drawing wherein Fig. 1 is a diagrammatic representation of a pulsing system embodying my invention, and Fig. 2 is an equivalent circuit diagram illustrating the invention.

In Fig. 1, the numeral 1 indicates generally an amplifier or like device which may include two electron discharge devices 2 and 3 each having a cathode 4, an anode 5, and a control electrode 6. The anodes 5 are connected respectively to opposite ends of a winding 7, the cathodes 4 are connected together and preferably grounded, and the control electrodes 6 are connected respectively through grid resistors 8 and condensers 9 to a source of preferably radio frequency oscillations indicated generally by the rectangle 10. Source 10 may be a balanced oscillator of a usual type or such as described in the application of Donald E. Watts and Paul C. Gardiner, Serial No. 311,532, filed December 29, 1939 and assigned to the same assignee as the present invention (now Patent 2,400,796 granted May 21, 1946), or any other suitable source such as an intermediate amplifier. The oscillator 10 or intermediate amplifier is adapted to be keyed by a keying device of any

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suitable form represented generally by the rectangle 11.

The control electrodes 6 are connected through choke coils 12 and a resistor 13 to a source 14 of biasing potential which is of such value that the devices 2 and 3 are in the non-conducting or cut-off condition when radio frequency potentials are not being impressed on the control electrodes 6 from the oscillator 10. Capacitors 15 in series are connected across the winding 7 and the center connection of these capacitors is connected to ground. The anode-cathode circuit 16 of devices 2 and 3 includes a source of relatively high unidirectional potential (not shown) connected through a choke coil 17 across the middle point of output winding 7 and cathodes 4. The choke 17 is bypassed to ground by a condenser 18.

The circuit connections of circuit 16 include a condenser 19 in series with the unidirectional voltage source and a resistor 20 in shunt with the latter condenser. This resistor-capacitor shunt combination constituted by condenser 19 and resistor 20 is so arranged that its time constant is preferably longer than the pulse duration.

The output coupling winding 21 of the circuit, including output winding 7 and condensers 15, is connected to a load or utilization circuit (not shown) of any desired character. Neutralizing condensers 22 and 23 are preferably provided respectively between the anode of each one of the devices 2 and 3 and the control electrode of the other to prevent undesired oscillations.

In operation of the above described system, assuming initially that anode potential from the source of unidirectional potential is being supplied to the anode-cathode circuit 16 of devices 2 and 3 and that the negative biasing potential sufficient to render devices 2 and 3 non-conducting is being supplied from source 14 to the control electrodes 6, then current flows in output circuit 16 and in the load circuit associated therewith when the oscillator 10 is operated by keying device 11 to impress pulses of radio frequency oscillations alternately upon the control electrodes of devices 2 and 3.

In accordance with my invention, the potential across the unidirectional potential source is of such high value that the pulses produced in normal keying of the system are of relatively very high peak value, and of a value preferably substantially higher than it is usually desirable to permit the devices 2 and 3 to transmit during continuous operation or key-closed condition of the system because of the danger, under these

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conditions, of damage to the devices 2 and 3 from overloading. These extremely high power peak pulses may be produced at any desired speed, for example, at speeds of approximately 40 to 400 cycles per second. To protect the devices 2 and 3 from the above mentioned overloading in case the system is left in continuous operation or key-closed condition, the shunt combination comprising condenser 19 and resistor 20 is so arranged that its time constant is preferably substantially longer than the time periods of the pulses. The manner of operation of the shunt combination 19 and 20 in performing this protective function will be explained hereinafter.

In the use of the system to produce the normal high power peak pulses, the series of short pulses of unidirectional current in circuit 16 are conducted through the condenser 19 which in the normal condition of operation offers a low or negligible impedance to the current flow. Therefore during this normal condition of operation, substantially the full potential of the source is impressed across the anodes and cathodes of the devices 2 and 3 thereby producing the relatively very high pulse peak current values above mentioned, without, however, subjecting the devices to the danger of damage from overloading.

Assuming, however, that the system is left in continuous operation or key-closed condition, then substantially continuous current flows in the circuit 16 instead of the unidirectional series of rapidly recurring short pulses which occur under normal or keying conditions. This continuous current charges the condenser 19 which is shunted by the resistor 20. Discharge current from the condenser 19 flowing in shunt resistor 20 produces a potential drop which is, however, opposite in sign to the potential of the unidirectional potential source. Therefore, under this described condition of continuous or key-closed operation of the system, after a short time interval, e. g., the time for the condenser 19 to fully charge, the potential impressed across the devices 2 and 3 is not the full potential of the unidirectional potential source but is this source potential minus the drop through the resistor 20, the resultant lower potential being preferably the potential corresponding to the given maximum continuous power output capability of the discharge devices 2 and 3.

In the use of the above-described system the series of short high power pulses of radio-frequency oscillations produced in the discharge devices 2 and 3 upon keying of the oscillator 10 may be supplied through the coupling coil 21 to any desired load or utilization circuit (not shown). In producing the series of pulses, oscillations of radio frequency are preferably kept out of the source of unidirectional potential by any suitable filtering means such as provided, for example, by condenser 18 and choke coil 17.

For a mathematical consideration of the circuit including the resistor-shunt combination constituted by condenser 19 and resistor 20 the simple equivalent circuit shown in Fig. 2 applies.

In Fig. 2, E represents the potential of the unidirectional potential source of Fig. 1, E_c represents the potential across the condenser 19, i represents the total current in circuit 16, i_c and i_R represent the current in condenser 19 and resistor 20 respectively, C represents the capacitance of condenser 19, R the resistance of the resistor 20, R_L the load resistance, and t the time interval from the instant that the switch is closed

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(or $t=0$) to the instant that the switch is opened. Under these conditions,

$$i = i_c + i_R$$

$$i_c = \frac{E}{R_L} \left\{ \epsilon - \frac{(R_L + R)t}{RR_L C} \right\}$$

$$i_R = \frac{E}{R_L + R} \left\{ 1 - \epsilon - \frac{(R_L + R)t}{RR_L C} \right\}$$

$$E_c = Ri_R = \frac{ER}{(R_L + R)} \left\{ 1 - \epsilon - \frac{(R_L + R)t}{RR_L C} \right\}$$

At the instant switch S is closed, the current through R is zero and the current through

$$C = \frac{E}{R_L}$$

During the time interval following the closing of the switch, the current i_c decreases and the current i_R increases until

$$i_R = \frac{E}{R_L + R}$$

for the steady condition.

The time constant of the above mentioned circuit R and C may be made substantially longer than the pulse. The time constant may be, for example, such that if the key is closed for a long period of time the RI drop in resistor R will prevent accidental damage to the tubes which might occur because of high current and plate dissipation.

During pulse keying, the RC circuit if of suitable values will not allow a steady state condition to be reached. Thus, high peak power output is obtained.

When the pulse is removed by opening the switch, the capacitor C discharges into resistor R in the opposite direction from that of the current by which it was charged. It is assumed that the period during which the pulse is off will be of sufficient magnitude to allow the capacitor to be substantially discharged, thereby allowing the pulse to start again at nearly the same level of power each time. Such magnitude of the time period is not essential, but it results in a higher level of peak power.

For a mathematical consideration of the RC circuit for the period from the instant that the switch is first opened to the instant it is again closed, the simple equivalent circuit of Figure 2 again applies.

In this latter case t represents the time from the beginning of closing switch S to the instant when switch S is again closed, $t-t_1$ the time from the instant that switch S is opened to the instant when switch S is again closed, and, t_1 the time measured from the instant switch S is first closed to the instant switch S is opened. Then,

$$i_c = -i_R$$

$$i_R = \left(\frac{E}{R_L + R} \right) \left\{ 1 - \epsilon - \frac{(R_L + R)t_1}{RR_L C} \right\} \epsilon - \frac{(t-t_1)}{RC}$$

$$E_c = Ri_R = \frac{ER}{(R_L + R)} \left\{ 1 - \epsilon - \frac{(R_L + R)t_1}{RR_L C} \right\} \epsilon - \frac{(t-t_1)}{RC}$$

In the system above described illustrating the invention the means for producing current pulses in accordance therewith includes two three-electrode space discharge devices and a keyed oscillator. It will be understood, however, that the invention is not limited to such devices and arrangement but that various other pulse producing devices and arrangements may be em-

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played in connection with the protection means comprising the resistor-capacitor means.

A pulse generating system as described herein is particularly applicable to the supplying of ping- ing circuits, for underwater signalling for exam- ple. The system is, however, applicable to a large variety of other uses, and in particular to any ap- plication requiring high maximum peak pulse power from a transmitting apparatus meeting especially low minimum weight and space re- quirements.

My invention has been described herein in a particular embodiment for purposes of illustra- tion. It will be understood, however, that the in- vention is susceptible of various further changes and modifications and that by the appended claims I intend to cover any such modifications as fall within the true spirit and scope of my in- vention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A high intensity pulsing circuit comprising, in combination, an electron discharge device hav- ing input and anode circuits, means for recur- rently impressing a signal pulse of predetermined duration upon said input circuit, said device hav- ing increased conductivity during said pulse and being capable of safe continuous operation with a predetermined maximum anode potential if sig- nals are continuously supplied for longer than the duration of said pulse, a source of anode op- erating potential of substantially higher value than said predetermined potential, and means for impressing the potential of said source upon the anode of said device through a current-limiting impedance network comprising a condenser and a resistor in parallel, said network having a time constant longer than the duration of said signal pulse, and said resistor having a value sufficient to limit the anode potential to a value not ex- ceeding said maximum value under steady state conditions of continuously-applied signals.

2. A high-intensity pulsing circuit comprising,

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in combination an electron discharge device hav- ing grid and anode circuits, keying means for impressing periodic spaced pulses of high fre- quency signals upon said grid circuit, means for impressing a negative bias potential on said grid circuit sufficient to maintain said device cut off except when signals are impressed, said device be- ing capable of safe continuous operation with a certain maximum anode potential if input signals are impressed for longer than a predetermined pulse duration, a source of anode operating poten- tial of substantially higher value than said max- imum potential, and means for impressing the potential of said source upon said anode circuit through an impedance network comprising a con- denser shunted by a resistance, said network hav- ing a time constant longer than said predeter- mined pulse duration and said resistance having a value sufficient to limit the anode potential to a value not exceeding said maximum value under steady state conditions of continuously-applied input signals.

DONALD E. WATTS.

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