

Oct. 28, 1947.

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2,429,809

RADIO LOCATING EQUIPMENT

Filed Sept. 17, 1942

4 Sheets-Sheet 1

Fig. 1.

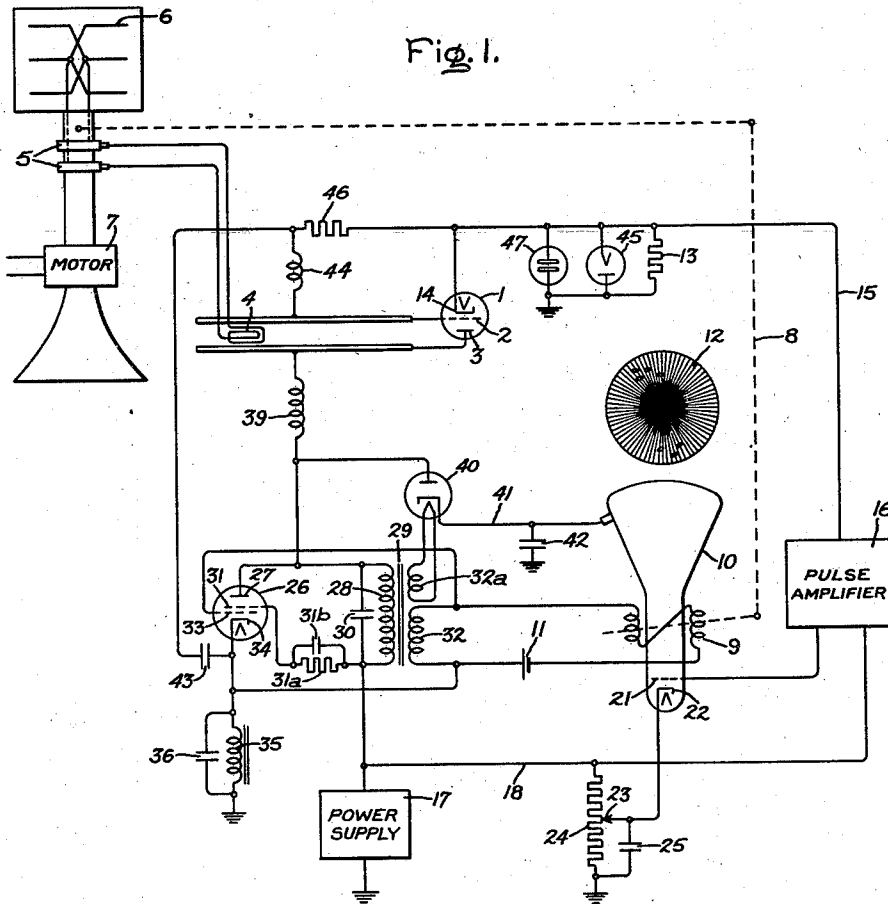
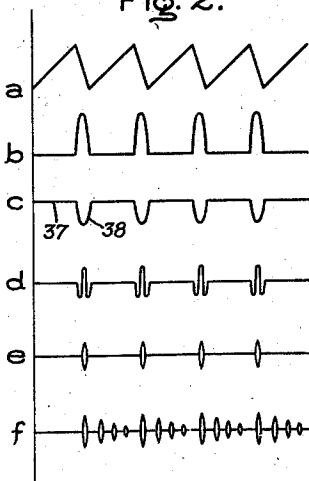


Fig. 2.



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4 Sheets-Sheet 3

Fig. 7.

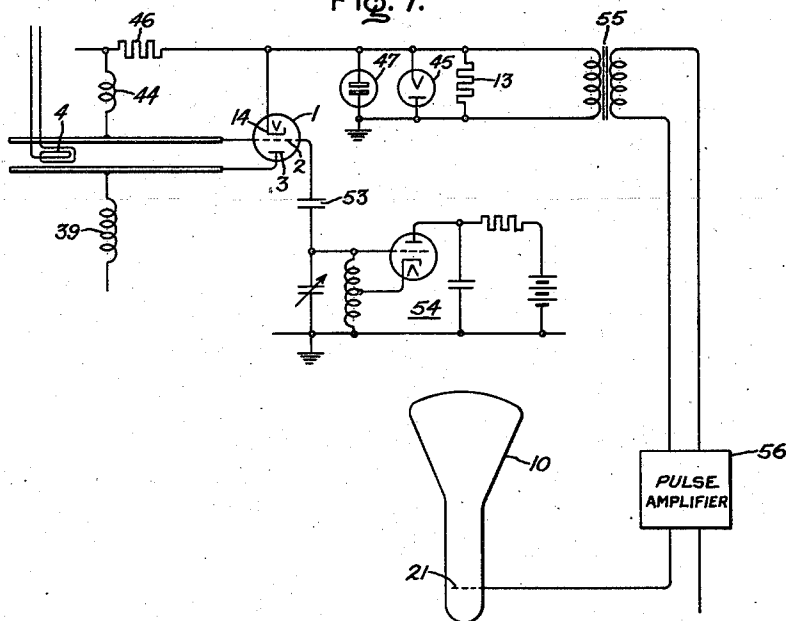


Fig. 8.

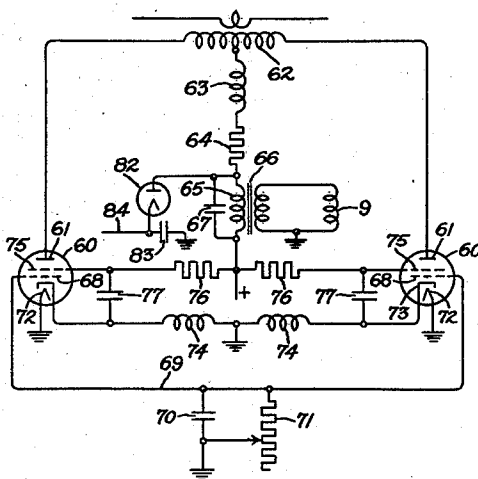


Fig. 9a.

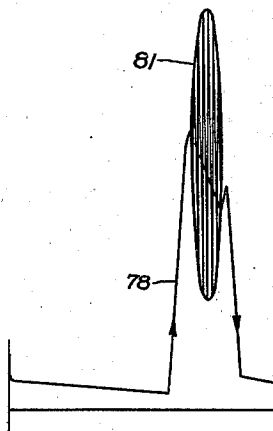


Fig. 9b.

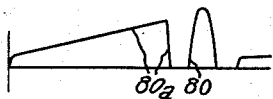
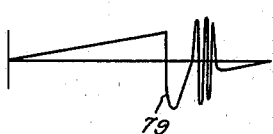


Fig. 9c.



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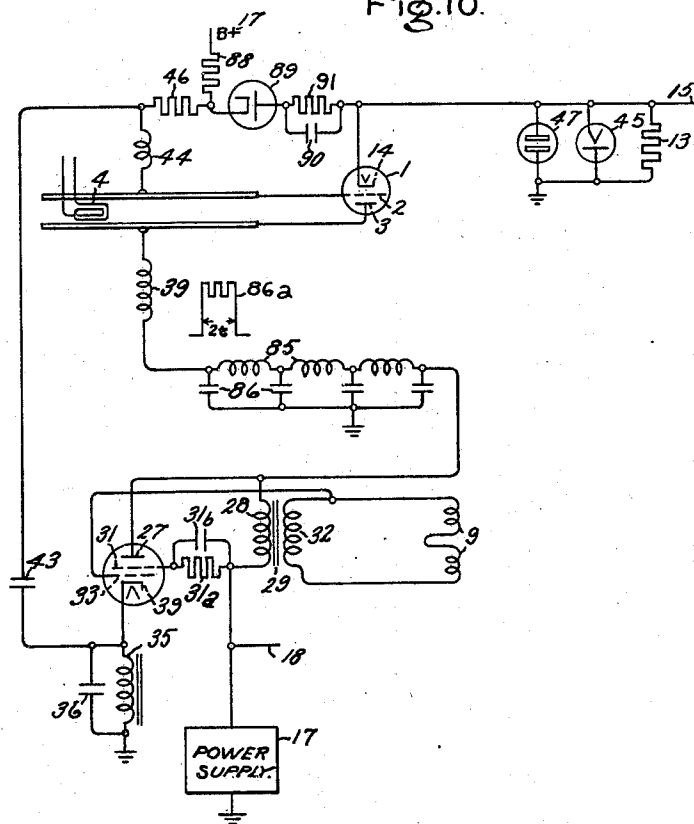
2,429,809

RADIO LOCATING EQUIPMENT

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4 Sheets-Sheet 4

Fig. 10.



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UNITED STATES PATENT OFFICE

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RADIO LOCATING EQUIPMENT

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Application September 17, 1942, Serial No. 458,631

15 Claims. (Cl. 250—1.62)

1

The present invention relates to radio locating equipment which in general comprises a transmitter for sending out directional pulses of radio waves, a receiver for echoes of the transmitted pulses (either from reflections or from pulse transmission equipment excited by the pulses), and equipment for coordinating the transmitter and receiver.

An object of my invention is to provide a simplified equipment in which the transmitter serves as a receiver during the intervals between transmitted pulses.

Another object of my invention is to provide improved circuits for controlling the transmitter for transmission and reception, for increasing the sharpness of the transmitted pulses, and for synchronizing the transmitted pulses with the received echoes.

The novel features which I believe 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 drawings in which Fig. 1 represents radio locating equipment embodying my invention; Fig. 2 illustrates operating characteristics of Fig. 1; Figs. 3 and 5 are modifications of the transmitter for the equipment of Fig. 1; Figs. 4 and 6 respectively illustrate operating characteristics resulting from the use of the transmitters of Figs. 3 and 5 in the equipment of Fig. 1; Fig. 7 is a modification of a receiver circuit; Fig. 8 is a modification of the transmitter and sweep circuit; Figs. 9a, 9b, and 9c illustrate operating characteristics of Fig. 8; and Fig. 10 is another modification of the Fig. 1 equipment.

Referring to the drawings, there is shown radio locating equipment having a tube 1 in which the grid 2 and the anode 3 are connected to a half-wave length transmission line suitably coupled, for example through a circuit 4 and slip rings 5, to a directive or beam antenna 6. In practice it is contemplated that the tube 1 and its associated transmission line may be a cavity resonator, the circuit 4 may be a wave guide, and the antenna 6 may be of the paraboloid type, but it is not considered to be necessary that these well known elements be illustrated in the present application. The antenna is rotated by a motor 7 at a suitable scanning frequency, for example one revolution per second, and the angular position of the antenna determines the direction of the transmitted

2

pulses and of the received echoes. Through suitable arrangements, indicated by dotted lines 8, a yoke 9 surrounding the neck of a cathode ray tube 10 is rotated in synchronism with the antenna. By means of a sweep circuit, hereinafter described, and an adjustable bias 11, the magnetic field produced by the yoke deflects the beam in radial traces indicated by the lines 12, each trace starting at the center with the transmitted pulse and progressing at a uniform rate toward the circumference of the cathode ray tube screen. Because the yoke and antenna are moved synchronously, the angularity of the traces varies with the angularity of the antenna.

The incoming signals, the echoes from the objects to be located, appear, as hereinafter described, in a resistance or impedance 13 connected from ground to the cathode 14 of the tube 1 and are fed through a conductor 15 to a pulse amplifier 16. The pulse amplifier is connected to a power supply 17 by a conductor 18 and feeds the amplified signal to the grid 21 of the cathode ray tube as a pulse which drives the grid suddenly positive (or negative) and produces a brief increase (or decrease) in beam intensity which appears by contrast as a bright (or dark) spot on the screen.

Because the angular position and distance of the spots from the center correspond to the orientation and distance of the objects from which echoes are received, a map may be placed over the screen on which the locations will be shown directly. The contrast between the spots and the screen background is controlled by a connection from the cathode 22 of the cathode ray tube 10 to an adjustable tap 23 on a resistance 24 shunted across the power supply. The tap-to-ground section of the resistance 24 is shunted by a large by-pass condenser 25 so as to prevent degeneration.

The pulse transmission is controlled by a sawtooth or sweep circuit oscillator having a tube 26 with its anode 27 energized from the power supply 17 through the primary winding 28 of a transformer 29. The primary winding is shunted by a condenser 30 and is connected across the anode 27 and screen grid 31, the connection of the screen grid being through a resistance 31a shunted by a condenser 31b. The transformer secondary winding 32 is connected in series with the yoke 9 and across the control grid 33 and cathode 34. The connections of the secondary to the control grid are such that the induced voltage applied to this control grid is opposite in sign to the induced voltage applied to the anode 27 from the primary.

3

The cathode is connected to ground through an inductance 35 shunted by a condenser 36.

The anode current of the tube 26 is shown at "a" in Fig. 2. At the start, the anode current is low, the anode voltage is less than the power supply voltage by the induced voltage drop through the transformer 29; the screen grid voltage is less than the power supply voltage by the voltage across condenser 31b; and the control grid voltage is positive with respect to the cathode due to the induced voltage in the secondary winding 32.

The anode current increases until the tube starts to saturate, the rate of increase being controlled by the screen grid voltage through the resistance 31a and the condenser 31b. At the start of saturation the rate of increase of anode current decreases and the control grid is driven in a negative sense by the induced secondary voltage, i. e., it becomes less positive. This effect is cumulative, i. e., the faster the current decreases, the greater the decrease in grid voltage. This quickly results in an induced negative bias on the control grid. The practical result is a sudden open circuit of the tube during the steep slope of the sawtooth wave.

The voltage on grid 33 is represented at "c" in Fig. 2, the flat sections 37 corresponding to the positive grid voltage while the anode current increases at a constant rate and the dips 38 corresponding to the negative driving of the grid during the sudden interruption of the anode current.

The sudden interruption of the anode current causes induced transient voltages in the transformer primary winding 28 (the anode transient), represented at "b" in Fig. 2, and also in the inductance 35 (the grid transient), represented at "d" in Fig. 2. The induced voltage in the transformer primary, which may rise twenty to thirty times the voltage of the power supply (5,000-10,000 volts for a 300-volt power supply), is applied through a radio frequency choke 39 to the anode 3 of the transmitter tube 1. The anode transient oscillation frequency is determined by the reflected inductance in the transformer primary 28 and the total capacity to ground associated with the primary. The transient voltage in the inductance 35 (the grid transient), due to the circuit constants, is at a higher frequency than the anode transient and starts in a negative direction from the voltage at the interruption of the anode current. The grid transient is applied through a condenser 43 and a radio frequency choke 44 to the grid 2 of the transmitter tube 1 driving the grid negative until the anode voltage has built up to nearly the maximum voltage of the anode transient. While the anode voltage is building up, the cathode 14 of the transmitter tube is held at or near ground potential by a diode 45 connected between the cathode and ground in shunt with the resistance 13. Without the diode there would be a rise in negative potential on the cathode (through a resistance 46 connected between the cathode and the choke 44) which would decrease the effective grid bias and allow oscillation of the transmitter tube before the anode voltage had built up to the desired high value. As the negative bias passes through its maximum and starts to decrease while the potential on the anode 3 is still increasing, a point is reached at which the transmitter tube breaks into oscillation, and, due to the high anode voltage at this time, a pulse of radio waves having a steep front and of short duration is transmitted over

4

the directive antenna 6. A sparker 47 connected between the cathode 14 and ground holds the cathode to a small positive voltage (for example 30 volts) during pulse transmission and prevents an effective loss of anode voltage in the resistance 13. The steep front is due to the sudden starting of oscillation at a high effective anode voltage. The short duration of the pulse results from the rapid decrease exponentially of the trailing edge, due to rapid discharge of energy stored in the condenser 30. The envelopes of the transmitted pulses are represented at "e" in Fig. 2.

Following the transmitted pulse, the anode potential on the transmitter tube drops to a value somewhat less than the voltage of the power supply and the tube functions as a self-quenched super-regenerative detector. The quench frequency (of the order of 4 megacycles for a one-microsecond transmitted pulse) is controlled largely by the time constant of the condenser 43 as well as the stray circuit capacities and the resistance 46 which are effectively paralleled through ground since the effect of the resistance 13, the inductance 35, and the condenser 36 is negligible.

Due to the directivity of the antenna 6, echoes are received from the direction of the transmitted pulses. The pulse envelopes appearing at the pulse amplifier are indicated at "f" in Fig. 2, the larger pulses corresponding to the transmitted pulses and the smaller pulses corresponding to the echoes. The echoes of course will be spaced according to the distance of the reflecting objects rather than at regular intervals as indicated.

The sweep circuit for the cathode ray tube is automatically synchronized by the sawtooth oscillator circuit. There is no problem of synchronizing a separate transmitter and receiver.

From one aspect, the sawtooth oscillator can be considered as keying the transmitter tube for high power or intensity oscillation during pulse transmission and for low power or intensity oscillation during reception, the high and low intensity oscillations occurring respectively during the retrace and trace on the cathode ray tube. During the trace, energy is stored in the primary 28 by the current flowing through the branch circuit through the tube 26. At the retrace, the tube 26 is suddenly driven to cutoff interrupting the current in the branch circuit and causing the release of the stored energy at an anode voltage relatively high compared to the voltage of the power supply.

The anode transient (Fig. 2b) is also used to supply high voltage to the cathode ray tube 10 through a high voltage rectifier tube 40 and a conductor 41. A condenser 42 connected between the conductor 41 and ground smoothes the rectified transient. The cathode heater current for the high voltage rectifier tube 40 may be obtained from an auxiliary transformer winding 32a which will have a similar transient voltage.

For high scanning speeds it is expected that the transmitter will be operated at high frequencies (from 400 to 3,000 mc.) since these frequencies permit the use of a smaller antenna which will not be subject to as large centrifugal forces.

In Figs. 3 and 5 are shown modifications of the arrangement for controlling the transmitter tube which may be substituted in the equipment of Fig. 1, corresponding parts being indicated by the same reference numerals to aid in the substitution. In each of these modifications the

5

difference from the Fig. 1 construction lies in the connection between the sweep circuit oscillator and the transmitter tube 1. The changes in Fig. 3 consist in the omission of the inductance 35 and the condensers 30 and 36 and in the connection of the condenser 43a and the resistance 46a, in series between the cathode 14 of the transmitter tube and the secondary winding 32 of the transformer 29 with the grid 2 connected to a point between the resistance and condenser. The operation of the sweep circuit is unchanged. The sawtooth sweep current (Fig. 4a), the anode transient (Fig. 4b) and the voltage on the grid 33 (Fig. 4c) are unchanged and are respectively identical with Figs. 2a, 2b, and 2c. The difference is that the transmitter grid 2 receives a biasing voltage direct from the transformer secondary through the condenser 43a and resistance 46a. During transmission these serve as a differentiating circuit to change the induced secondary voltage (Fig. 4c) to the form shown at "d" in Fig. 4. The differentiation is due to the lower impedance of the condenser at the higher frequencies which makes the circuit more responsive to the steep slope of the induced secondary voltage (Fig. 4c). While the voltage on the anode 3 (Fig. 4b) is rising, a negative voltage is induced in the transformer secondary 32 (Fig. 4c), which appears at the grid 2 as the voltage shown at Fig. 4d which holds the tube non-conductive while the anode voltage is building up. As the anode voltage approaches its peak value, its rate of increase falls off and the voltage applied to the grid through the differentiating circuit 43a, 46a decreases. Shortly before the peak anode voltage, the negative grid bias becomes insufficient to hold the tube off and the tube oscillates, transmitting pulses of radio waves having envelopes indicated at "e" in Fig. 4. Following the transmission of the pulse, the voltage on the anode 3 drops to something less than the voltage of the power supply, and the tube is conditioned for superregenerative reception of the echoes, as in the Fig. 1 construction. The pulse envelopes appearing in the pulse amplifier are indicated at "f" in Fig. 4 where the large pulses correspond to the transmitted pulses and the smaller pulses correspond to received echoes.

In Fig. 5, as in Fig. 3, the operation of the sweep circuit is the same as in Fig. 1. The sawtooth sweep current (Fig. 6a), the anode transient (Fig. 6b), and the voltage on the grid 33 (Fig. 6c) are respectively identical with Figs. 2a, 2b, and 2c.

In Fig. 5 the grid 2 of the transmitter tube 1 is grounded through a radio frequency choke 50 and the quench resistance 46, and the bias which prevents oscillation of the tube 1 during the build-up of the anode voltage is obtained by connecting the cathode 14 to the primary 28 of the transformer 29 through a conductor 51 and a condenser 52 which tends to differentiate the positive anode pulse (Fig. 6b). As the voltage on the anode 3 builds up to a high positive value, the voltage on the cathode becomes positive with respect to the grid and produces the effect of a negative grid bias. The cathode voltage is limited by the sparker 47, and the cathode voltage accordingly is flat topped, as indicated at "d" in Fig. 6. Because of this limitation of the cathode voltage, the effective grid bias is kept from increasing and the tube 1 oscillates to transmit the pulses at the points slightly before the peak voltage on the anode. Because there is no tendency to make the cathode negative, the diode

6

45 is omitted. Following the transmission of the pulse, the voltage on the anode 3 drops to something less than the voltage of the power supply and the tube 1 is conditioned for superregenerative reception. The superregenerative oscillation is quenched as before by the resistance 46 but the condenser 43 can now be omitted with corresponding increase in quench frequency.

In Fig. 7 is shown an arrangement for superheterodyne reception of the echoes. The transmitted pulses are controlled by the sweep circuit oscillator (not shown) in the manner previously described in connection with Fig. 1, and corresponding parts are indicated by the same reference numerals.

In this construction the incoming signals at the tube 1 are mixed with the output of a local oscillator 54 to produce a beat frequency.

The oscillator can be connected in various ways to the tube 1 and in the present circuit is shown connected to the grid 2 through a condenser 53 to produce a beat frequency which appears across the cathode-to-ground resistance 13 and is fed through a transformer 55 and a receiver and pulse amplifier 56 to the grid 21 of the cathode ray tube 10 to produce the contrast spots indicating the position of the objects from which the echoes are received. The oscillator is effective only during the intervals between transmitted pulses so that this arrangement differs from the previously described construction only in the manner in which the echoes are received.

In Fig. 8 is shown a combined pulse transmitter and sweep circuit oscillator having two tubes 60 connected in push pull. The anodes 61 are connected together through an antenna coupling coil 62 connected at its mid point by a R. F. choke 63 and a resistance 64 to the upper end of the primary 65 of a transformer 66. The primary 65 is shunted by a condenser 67 and its lower end is connected to the power supply. The control grids 68 are connected together by a conductor 69, the conductor being grounded through a condenser 70 in parallel with an adjustable grid leak 71. The cathode heaters 72 are grounded. The cathodes 73 are isolated from ground by chokes 74 connected in series between the cathodes and grounded at the mid point. The screen grids 75 are each connected to the power supply by a resistance 76 high enough effectively to isolate the screen grids. The ends of the chokes 74 and of the resistances 76 adjacent the tubes are connected by condensers 77.

At the start of the sweep circuit cycle, the anode current flows from the power supply through the primary 65 to the mid point of the coupling coil 62 where it divides equally through the tubes 60 and returns to ground through the chokes 74. The anode current shown in Fig. 9b starts at a low value and gradually increases to a peak determined by saturation of the tubes. At saturation the current cannot increase further and the rate of change of anode current

$$\left(\frac{di_p}{dt}\right)$$

decreases causing a corresponding increase in anode voltage which tends to appear at the screen grid 75 and the cathode 73 due to the distributed capacity between the plate and screen grid and between the screen grid and the cathode and ground. These capacities act as a capacity divider which is effective throughout a wide range of frequencies since the screen grid and cathode are isolated from ground by the large resistance

76 and the choke 74. The condenser 77, which is larger than the distributed capacities, ties the screen grid and cathode together so that both have the same change. The increase in anode voltage at tube saturation accordingly results in an increase in cathode voltage without a corresponding increase in the voltage of the control grid 68, or, in other words, in an increase in the negative bias of the control grid which causes a further decrease in anode current. The effect is cumulative resulting in a sudden interruption of the anode current as in Fig. 1. The anode voltage rise upon interruption of the anode current (78 in Fig. 9a) is a transient having a frequency determined by the reflected inductance in the primary 65 and the shunting condenser 67.

The anode transient is differentiated by the effect of the distributed capacity between the anode 61 and the screen grid 75 in series with the resistance 76 so the screen grid voltage falls from its maximum before the anode voltage reaches its maximum. Since the screen grid 75 and the cathode 73 are tied together by the condenser 77, the differentiated voltage on the screen grid produces a negative bias on the control grid 68, indicated at 79, on the control grid voltage curve (Fig. 9c), which passes its maximum before the anode voltage reaches its maximum. As the grid bias becomes less negative the tubes suddenly become conductive, as indicated at 80 on the anode current curve (Fig. 9b) and break into radio frequency oscillation as indicated by the envelope 81 on the anode voltage curve (Fig. 9a). The radio frequency oscillation may be self quenched due to the use of a high grid resistance 71. The cycle starts again as soon as the condenser 70 discharges through the grid leak 71 so that energy storage can again start in the primary 65.

In Fig. 8, the tubes 60 act alternately as a sawtooth oscillator producing the low voltage sawtooth current shown at 80a in Fig. 9b and as pulse oscillator producing the high voltage pulse shown at 80 and 81. In terms of the Fig. 1 circuit, the tubes 60 alternately perform the function of the tube 26 and the tube 1.

As in the previous circuits, the sawtooth sweep current in the transformer secondary is connected to the cathode ray tube yoke 9, and the anode transient is rectified by a high voltage rectifier tube 82 and is fed through a filter condenser 83 to the cathode ray tube by a conductor 84.

The Fig. 8 circuit may be used for reception by coupling a local oscillator to mix with the received signals and by adding (as shown in Fig. 7) the sparker 47, the resistance 13 and the coupling transformer in series with the chokes 74 and the common ground.

In all of the circuits, a transient anode voltage, from the energy stored in an inductance while the sweep current is increasing, is suddenly applied to the transmitter tube anode during the brief interval while the sweep current is decreasing. The short interval for releasing the stored energy results in a high anode voltage. Pulse transmission is controlled by a grid transient, which holds the tube off until the anode voltage approaches its peak value. The high anode voltage results in a rapid dissipation of the stored energy as a pulse of radio waves.

During the interval between pulses, the anode voltage drops and the circuits are conditioned for reception. The problem of synchronizing is eliminated because the transmission and reception are controlled by the common sweep circuit.

In Fig. 10 is shown a modification of the equip-

ment of Fig. 1 designed to obtain a sharper pulse during transmission and an improved quenching action during reception.

The anode transient from the primary 28 is applied to the anode 3 of the transmitter tube 1 through an artificial transmission line having a plurality of sections of inductances 85 and condensers 86. The total value of condensers 86 may replace condenser 30 in Fig. 1. The transmission line is designed so that its surge impedance Z_0 is equal to the anode impedance.

$$\left(\frac{E_p}{E_r}\right)$$

of the transmitter tube 1 and so that the time of travel of a current wave from one end to the other is equal to half the desired duration of the transmitted pulse. For the transmission line shown the surge impedance is equal to

$$\sqrt{\frac{L}{C}}$$

where L equals the total inductance and C the total capacitance of the line, and the time delay of the line "t," the time of travel of a current wave one way through the line, is equal to $\sqrt{LC}$. Choke 39 would be made about one-half the inductance of any of the sections 85.

As the anode transient builds up due to the sudden interruption of the current through the tube 26, the transmitter tube is kept from oscillating until the anode transient has been built up by the grid transient obtained from the inductance 35 and condenser 36 in the manner described in connection with Fig. 1. When oscillation starts a current wave flows from the anode 3 back through the transmission line to the primary winding 28 which, due to its high inductance, is an effective open circuit. The current wave accordingly is reflected with reversed sign and travels back along the transmission line to the anode and upon arrival at the anode (a termination having an impedance equal to the surge impedance of the line) cancels the anode current and abruptly terminates the oscillation. The anode pulse indicated at 86a, consists essentially of a square wave of a width equal to $2t$ (twice the time delay of the line) having abrupt leading and trailing edges with a number of small superimposed harmonics equal to the number of sections in the transmission line.

The operation of the transmission line to sharpen the pulses is not limited to the particular pulsing arrangement but is generally applicable to pulse systems.

The quench circuit for superregenerative reception differs from that shown in Fig. 1 in that the quench resistance 46 is connected to the power supply 17 through a grid leak 88 and is connected to the cathode 14 through a diode 89 in series with a condenser 90 paralleled by a resistance 91. The effect of the diode and its associated condenser and resistance is to maintain automatically an optimum negative grid bias during transmission.

During reception the condenser 90 holds a high negative charge so the diode 89 is biased off. The active circuit elements of the superregenerative quenching circuit are the condenser 43 and the stray circuit capacities, the resistance 46, the grid leak 88 and the voltage source 17. The oscillation is quenched by the charge built up on the condenser 43. The time for discharging the condenser to permit the starting of another cycle of superregenerative oscillation is decreased by hav-

ing the final voltage positive instead of ground potential as in Fig. 1.

While I have shown particular embodiments of my invention, it will be understood that many modifications may be made without departing from the spirit thereof, and I contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

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

1. In a pulse transmitter, an oscillator comprising an electron discharge device having anode and grid circuits, means for applying to the anode circuit a voltage pulse having an appreciable time of build-up, and means responsive to current in said anode circuit for applying to the grid circuit a voltage pulse in the sense to hold the oscillator off until the anode circuit voltage has built up to the desired value.

2. In a pulse transmitter having exciting and control circuits, a sawtooth oscillator, inductance means in series with the oscillator for storing energy during the gradual increasing slope of the oscillator and suddenly releasing the energy during the return slope of the oscillator, and transient circuits including said inductance means for supplying a transient pulse voltage having an appreciable time of build-up to the exciting circuit of the transmitter and to supply a transient pulse voltage for the control circuit of the transmitter to hold said transmitter off until said first transient has built up whereby the pulsing of the transmitter starts at a high voltage.

3. In a pulse transmitter, an oscillator having anode and grid circuits, means for applying to the anode circuit an oscillatory transient voltage pulse, and means for applying to the grid an oscillatory transient voltage in the sense to hold the oscillator off, said grid transient having a higher frequency than said anode transient whereby the grid transient passes its peak and decreases to a value insufficient to hold the oscillator off when the anode transient has built up to the desired value.

4. In a pulse transmitter, an oscillator having anode and grid circuits, means for applying to the anode circuit a transient voltage pulse having an appreciable time of build-up, means for applying to the grid circuit a transient pulse in the sense to prevent generation of oscillations, and means for limiting the grid transient to a value sufficient to prevent generation of oscillations until the anode transient has built up to the desired value but insufficient to prevent oscillation at higher values of the anode transient.

5. In radio locating equipment, a pulse transmitter and receiver including an oscillator having a tube with an anode, a cathode and a grid, said tube forming an operative part of the transmitter and of the receiver, means for exciting the tube for reception through an inductance connected to the anode, means for causing the storage of energy in the inductance during reception, and means for causing a sudden release of the energy in the inductance to obtain a high voltage pulse on the anode for transmission.

6. In combination, an oscillator having a tube with an anode, a cathode and a grid, an inductance in the anode power supply circuit effective upon saturation of the tube to apply an induced positive voltage to the anode, and differentiating means for applying said induced voltage to the

cathode to drive the cathode positive with respect to the grid and thereby drive the tube to cutoff, the differentiated voltage applied to the cathode passing through its maximum ahead of the induced anode voltage whereby the tube is pulsed at a high anode voltage.

7. In combination, an oscillator having a tube with an anode, a cathode, and a grid, means for applying to the anode a positive pulse voltage having an appreciable time of build-up, and differentiating means for applying said pulse voltage to the cathode to drive the cathode positive with respect to the grid and hold the tube off until the anode voltage has built up, the differentiated voltage applied to the cathode passing through its maximum ahead of the anode pulse voltage whereby the pulsing of the oscillator starts at a high voltage.

8. In combination, an oscillator having an anode and a grid circuit, means for applying to the anode circuit a pulse voltage having an appreciable time of build-up, and differentiating means for applying said pulse voltage to the grid circuit in a sense to hold the oscillator off until the anode voltage has built up, the differentiated voltage applied to the grid circuit passing through its maximum ahead of the anode pulse voltage whereby the pulsing of the oscillator starts at a high voltage.

9. In radio locating equipment, an electron discharge oscillator alternately usable to transmit periodic pulses of radio waves and intermediate the transmitted pulses for receiving echoes or reflections of the transmitted pulses from remote objects, said oscillator having an inductance in the anode power supply circuit, means supplying a gradually increasing current to the inductance while exciting the oscillator for receiving purposes, and means for suddenly interrupting the current after it has built up to produce an induced transient voltage in the anode circuit for pulsing the oscillator at a high voltage compared to the voltage of the power supply for transmitting purposes.

10. In combination, an oscillator, a transmission line connected at one end to the oscillator to excite the same and at the other end to an inductance, said transmission line having a characteristic impedance equal to the impedance presented by the oscillator during oscillation, means for impressing a pulse voltage on the transmission line remote from the oscillator whereby the voltage upon reaching the oscillator starts the oscillation and concurrently impresses a current wave on the line adjacent the oscillator, said current wave being reflected by the inductance at the end of the line opposite the transmitter with reverse sign whereby the reflected current wave cancels the current to the oscillator and terminates oscillation.

11. In combination, an electron discharge oscillator having an anode, a choke coil, a source of operating voltage connected across said choke coil, means abruptly to alter the current in said choke coil to produce a transient voltage thereon, a transmission line connected between said choke and said anode to supply said pulse thereto to cause said oscillator to oscillate and thereby supply a pulse back through said line, the constants of said line and choke coil being such that said last pulse is reflected from said choke coil back through said line to said oscillator and terminates the oscillation of said electron discharge oscillator.

12. In combination, an electron discharge oscil-

lator having an anode and a cathode, a choke coil, a source of operating potential connected across said choke coil, means abruptly to alter the current in said choke coil to produce a transient impulse thereon, a transmission line connected between said choke coil and the anode and cathode of said oscillator whereby said transient impulse is supplied as operating potential to said oscillator and said oscillator oscillates and produces a voltage variation across said line, said voltage variation being transmitted through said line and reflected by said choke coil to said oscillator to terminate oscillation by said oscillator whereby an oscillatory pulse is produced by said oscillator of length determined by the electrical length of said line.

13. In combination, a short wave electron discharge oscillator, having an anode, a cathode, and a grid, a source of operating potential connected between said anode and cathode through a choke coil, a second electron discharge device connected across said source and coil, means responsive to current in said coil and second device to interrupt current in said second device thereby to generate a sawtooth wave of current in said second device and high voltage transients on said coil, said high voltage transient serving as high operating voltage between the anode and cathode of said oscillator, and means responsive to current in said second device to apply a second transient between said grid and cathode poled to prevent oscillation by said oscillator until said first transient reaches a predetermined intensity.

14. In combination, an electron discharge short wave oscillator having an anode, a cathode and a control electrode, a source of operating potential connected between said anode and cathode through an inductance, a second electron discharge device having an anode connected to the terminal of said inductance remote from said source and a cathode connected through an impedance to the terminal of said source remote from said inductance, and having a control electrode, means responsive to predetermined build-up of current in said second device and said inductance to apply voltage pulse to said last control electrode abruptly to interrupt current in said inductance whereby a high transient voltage is produced between the anode and cathode of said oscillator, means to supply a voltage transient from said impedance to said first control electrode to prevent oscillation of said oscillator until said first transient reaches a predetermined level said second transient having a peak earlier than said first transient to permit

said oscillator to oscillate during the peak of said first transient.

15. In combination, an electron discharge short wave oscillator having an anode, a cathode and a control electrode, a source of operating potential connected between said anode and cathode through an inductance, a second electron discharge device having an anode connected to the terminal of said inductance remote from said source and a cathode connected to the terminal of said source remote from said inductance, and having a control electrode, means responsive to predetermined build-up of current in said second device and inductance to apply voltage to said second control electrode to interrupt said current abruptly to produce a voltage transient on said inductance and between said first anode and cathode, and means to differentiate the sawtooth current wave produced in said second device and to control the potential between the grid and cathode of said oscillator to prevent oscillation thereby until said transient has built up to a predetermined value.

GEORGE W. FYLER.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,239,678	Jobst	Apr. 29, 1941
2,055,883	Terry	Sept. 29, 1938
2,037,799	Koch	Apr. 21, 1936
2,088,842	Dallenbach	Aug. 3, 1937
2,103,090	Plebanski	Dec. 21, 1937
2,276,994	Milnowski	Mar. 17, 1942
1,418,023	Reisz	May 30, 1922
2,157,122	Dunmore	May 9, 1939
2,207,511	Geiger	July 9, 1940
2,212,173	Wheeler	Aug. 20, 1940
2,212,420	Harnett	Aug. 20, 1940
2,221,666	Wilson	Nov. 12, 1940
2,333,688	Shepard	Nov. 9, 1943
2,288,362	McArthur	June 30, 1942
2,045,224	Gebhard	June 23, 1936
2,018,569	Pettengill	Oct. 22, 1935
2,288,214	Summers	June 30, 1942
2,295,585	Lindquist	Sept. 15, 1942
2,084,157	McLennan	June 15, 1937
1,695,042	Fearing	Dec. 11, 1928
2,408,076	Labin	Sept. 24, 1946

FOREIGN PATENTS

Number	Country	Date
457,929	Great Britain	Dec. 8, 1936