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PULSE COMMUNICATION

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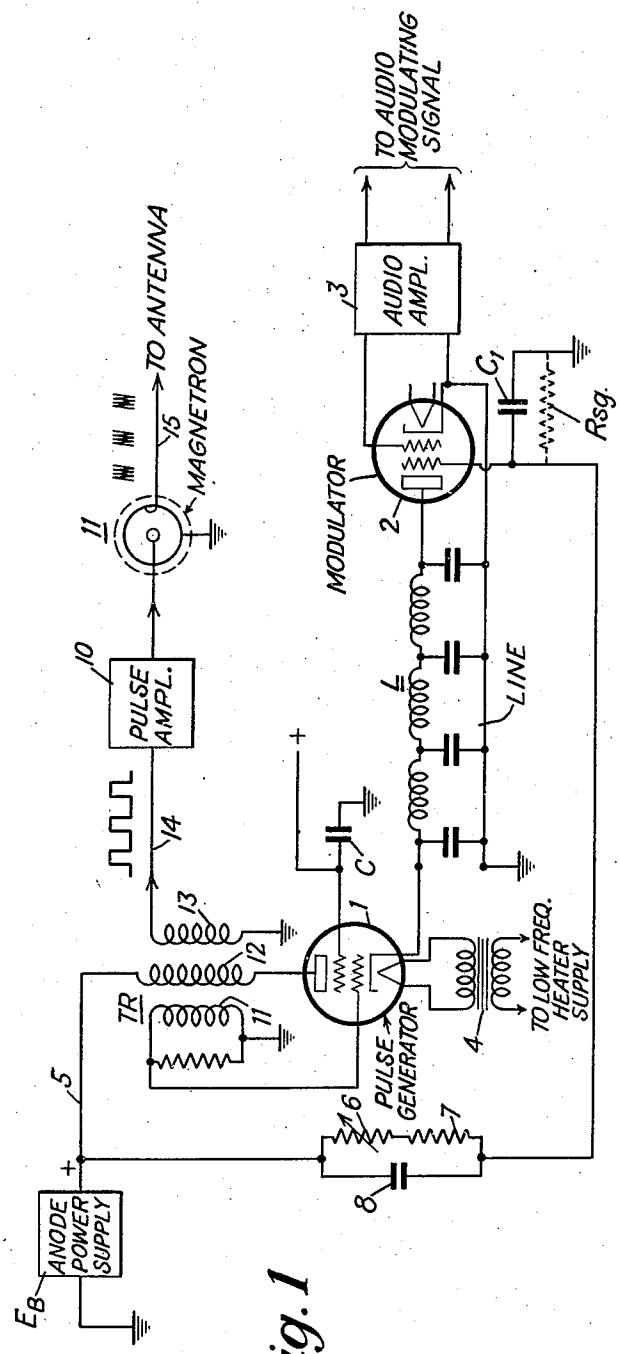


Fig. 1

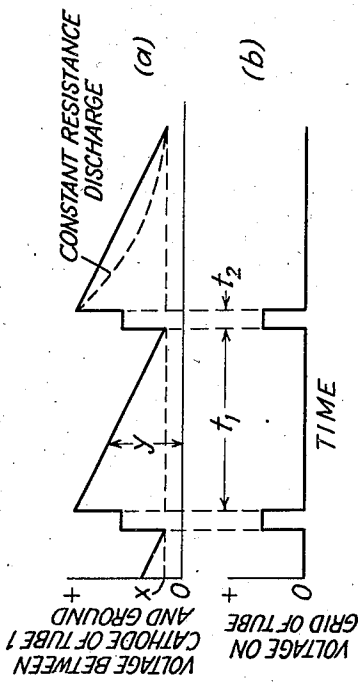


Fig. 2

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PULSE COMMUNICATION

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This invention relates to improvements in pulse type communication systems, and particularly to a method of and apparatus for generating short duration pulses and for modulating the repetition rate or frequency of these pulses in accordance with the signal to be transmitted. In one aspect, the present invention provides means for efficiently producing and modulating ultra high frequency pulses of the order of one microsecond duration and longer.

An important feature of the present invention lies in the use of a regenerative vacuum tube pulse generator in whose cathode circuit is a line whose electrical length determines the duration of the pulse to be generated. This line may be any suitable type but is preferably an artificial line in the form of a low pass filter consisting of several sections. Another feature of the invention includes the use of a modulating tube placed across the line in the cathode circuit of the pulse generator. This tube and the capacitance of the line determines the pulse repetition rate or frequency. A further feature lies in the arrangement for maintaining variations of the voltage supply for the anode of the pulse generator in phase with the voltage on the screen grid of the modulating tube, so as to maintain the pulse frequency or repetition rate independent of voltage variations on the anode of the pulse generator.

One advantage of the pulse generating system of the invention is that it is economical in power consumption because the pulse generator is conductive for only a small fraction of the total time. Another advantage of the invention is that the system is very stable in pulse length at the extremely short pulse duration intervals employed.

Other features and advantages of the invention will appear from a reading of the following description which is accompanied by a drawing wherein:

Fig. 1 diagrammatically illustrates one embodiment of the invention as applied to an ultra short wave radio pulse transmitting system; and

Fig. 2 graphically illustrates the operation of the pulse generator of Fig. 1.

Referring to the transmitting system of Fig. 1 in more detail, there is shown a pulse generator in the form of a vacuum tube pentode 1 whose control grid and anode electrode are connected to separate windings 11 and 12, respectively, of a three winding pulse transformer TR. Winding 13 of the pulse transformer derives rectangular wave output pulses of short duration and supplies

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these pulses by way of lead 14 to a pulse amplifier 10 for controlling a suitable ultra short wave generator such as a magnetron 11. The wave shape of these rectangular wave pulses is shown immediately above lead 14. The pulse transformer is so coupled to the pentode 1 that there is a regenerative action which gives very sharp increase of current in the tube 1 when the current is building up, and very sharp decay when the current is decreasing, thus providing pulses of sharp slopes or edges.

In circuit with the cathode of the pentode is an artificial line L, one end of which is connected between the cathode and ground, as shown, and the other end of which is connected across a constant current modulator pentode vacuum tube 2. In practice, the modulator tube may be placed anywhere along the length of the line L and even at the cathode end, if so desired. The line is shown in the form of a low pass filter consisting of several sections, but may be any suitable type. A coaxial line is not believed to be desirable for practical reasons because it would be too long and bulky compared to more compact available structures. The internal plate impedance of the modulating tube is designed to be high compared to the characteristic impedance of the line L. A signal modulating circuit is coupled across the control grid and cathode of tube 2 through an audio amplifier 3. The modulating signal may be speech or any other suitable signal.

The heater of the pulse generator tube 1 is supplied with heating energy from a low frequency power supply through an iron core transformer 4.

The anode of tube 1 is supplied with a positive polarizing voltage from anode power supply E_B over a lead 5 which extends to one terminal of winding 12. This same power supply furnishes positive potential to the screen grid of modulator tube 2 through an arrangement which serves to maintain the pulse repetition rate or frequency independent of supply voltage variations of E_B. This arrangement includes a pair of series resistors 6 and 7, and a shunt connected condenser 8 and will be further described later.

Condensers C and C_1 are by-pass condensers for the screen grids of tubes 1 and 2 respectively. Condenser C_1 is a by-pass condenser for the pulse frequency to maintain the screen grid of tube 2 at constant potential as far as pulse voltages are concerned. The dotted line resistor R_{sg} in shunt to condenser C_1 represents internal impedence to to ground of the screen grid of the modulator

tube 2. At this time it should be noted that the cathode of tube 1 is always maintained at a positive potential relative to ground, and supplies the anode voltage for the modulator tube 2 through the line L.

In the operation of the system of Fig. 1, an increase of current through the winding 12 will induce a voltage in winding 11 in such direction as to place a positive pulse on the control grid which will hasten or expedite the flow of current through tube 1. The flow of current through tube 1 will cause a pulse of voltage to flow down line L from the cathode end to the other end at which the modulator tube 2 is located. When this traveling pulse of voltage reaches the last end of the line, it will be reflected in phase and travel back along the line L to the cathode of tube 1 with a resultant voltage effectively double the initial voltage. When this resultant voltage reaches the cathode end of the line, it cuts off the current through the tube 1. The initial pulse voltage produced at the cathode end of the line L due to current flowing in tube 1 is of such relative polarity as to tend to cut down the current flow in the tube but is not of sufficient magnitude at this time to cut off the conductivity of the tube. But when the pulse returns to the cathode from the other end of the line with a resultant magnitude of twice the initial magnitude it is then of sufficient value to decrease the current flowing through the tube. When the current starts to decrease through the tube and through winding 12, the voltage induced in winding 11 by this decreasing current will reduce the positive voltage on the grid and hasten the cut off action. This regenerative action serves to give very sharp decay and very sharp increase of current in the tube.

The operation of the pulse generator 1 is graphically illustrated in Fig. 2, wherein graph (*a*) shows the variations in the voltage between the cathode of tube 1 and ground with respect to time, and graph (*b*) illustrates the variations in the voltage on the control gride of tube 1 with respect to time. Point X on the ordinate of graph (*a*) is the cut off voltage on the tube 1. The distance Y on graph (*a*) represents the instantaneous value of voltage across the cathode end of the line L at any instant, as measured from the slope of the curve to the zero voltage line. Time t_1 represents the time during which no current flows in the tube 1, while time t_2 represents the time of each pulse during which current does flow in tube 1. It will be seen that the duration of the pulses is very short compared to the time interval between them. The saw-tooth voltage wave of graph (*a*) appears between the cathode and ground, while the rectangular wave of graph (*b*) appears in the output circuit of the pulse generator 1 and is available in winding 13.

The effect of the pulse traveling down the line L and back again is to charge up the capacity in the line to a value equal to the resultant voltage. This voltage on the line capacity will keep the tube 1 cut off until the voltage in the line dissipates to a value below the cut-off value of the tube 1. This dissipation occurs through the modulator tube 2 and the time thereof may be increased or decreased by means of modulating potentials applied to the control grid of tube 2. The control grid of the modulator tube controls the effective impedance of the tube 2. Modulator tube 2 provides a constant current flow therethrough for any fixed value of bias on the control grid thereof.

In order to prevent variations in voltage of source E_B as applied to the anode of tube 1 from changing the pulse rate or frequency, due to variations of voltage across the line L, the screen grid voltage of the modulator tube 2 is varied in phase with the variations in the voltage on the anode of tube 1. The screen grid voltage for tube 2 is supplied through series resistors 6 and 7. In order for the foregoing in-phase relation to be maintained for rapidly varying voltages, such as power supply ripple voltages, in the anode supply E_B, the RC or the time constant of circuits 6, 7 and 8 should be equal to the RC of circuit R_{sg}, C_1.

The plus voltage supplied to the screen grid of tube 1 is maintained constant by a voltage regulator such as the RCA VR–150–30, or other suitable regulator. Because the voltage applied to the anode of this tube is much higher it is not desirable to regulate it in a similar manner.

This last feature may be further explained as follows: When the positive voltage on the anode of tube 1 increases, there is a larger positive voltage placed on the line L which must be dissipated faster if the same pulse repetition rate is to be maintained. By also increasing the screen voltage on modulator tube 2 at this time, there will be an increase of current through tube 2 and an increased rate of dissipation of the line voltage. On the other hand, a decrease in the positive voltage on the anode of tube 1 will be accompanied by a decrease in voltage on the screen grid of tube 2 with a concomitant decreased rate of dissipation of the line voltage.

The use of a constant current pentode for the modulator tube 2 has the advantage of permitting the instantaneous pulse frequency to be more constant because the slope of the saw-tooth wave (*a*) of Fig. 2 will intercept the cut-off line "X" at a steeper angle than would the curved line (shown dotted) which would result if the modulating device across the line acted as a constant resistance. It will be evident that variations in modulating potential applied to the control grid of tube 2 will vary the impedance of the tube 2 with a consequent variation in the dissipation rate of the voltage on line L. As a result of this, the pulse rate will be varied in dependence upon the modulating potentials.

As for the ultra high frequency oscillator 11, this is shown, diagrammatically only, as a magnetron having a cathode connected to the pulse amplifier 10 and a surrounding anode connected to ground.

A magnetic coil producing flux lines substantially parallel to the axis of the cathode of magnetron 11 is shown in dash lines. Output from the magnetron is taken from a loop located in the interior of the magnetron (as shown) and connected to a lead 15 extending to the antenna. This magnetron will be pulsed by the rectangular wave form short duration pulses impressed thereon by the pulse generator 1 to produce corresponding length pulses of ultra short wave energy which are radiated from the antenna, not shown. The wave form of these short wave pulses is shown above lead 15. Thus, microsecond duration pulses generated by the pulse generator will control the ultra high frequency oscillator to produce microsecond pulses of ultra short wavelength energy.

The term ground used in this specification and the appended claims is deemed to include any point or surface of zero radio frequency potential.

What is claimed is:

1. In a radio system having an electron discharge device, a pulse generator provided with a cathode, and a line of predetermined length having two ends, said line being connected at one end between said cathode and ground, method of generating a train of pulses which are each of short duration compared to the time interval between them, which includes initiating a voltage wave at the cathode end of said line at the start of current flow in said device, reflecting said wave from the other end of the line in a cophasal relation with the wave first traveling down the line to produce a resultant voltage of a magnitude appreciably greater than the initial voltage and in such sense as to completely extinguish the pulse at the time the reflected wave reaches said cathode end of the line, to thereby charge the capacity of the line at the value of said resultant voltage, and dissipating said voltage charge on the line in accordance with modulating potentials, whereby the reptition rate of the pulses generated by said device varies as a functional relation to said modulating potentials.

2. A pulse regenerative oscillator comprising an electron discharge device having a cathode, an anode and a control grid, separate coils in circuit with said anode and grid which are coupled to each other, and a line of predetermined length connected at one end between said cathode and ground and terminated at its other end such that a voltage wave traveling down the line from the cathode end will be reflected from said other end in-phase to produce a resultant voltage on said line effectively substantially double the initial voltage wave.

3. A pulse regenerative oscillator comprising an electron discharge device having a cathode, an anode and a control grid, separate coils in circuit with said anode and grid which are coupled to each other, a line of predetermined length connected at one end between said cathode and ground and terminated at its other end such that a voltage wave traveling down the line from the cathode end will be reflected from said other end in-phase to produce a resultant voltage on said line effectively substantially double the initial voltage wave, a modulator coupled across said line, and means for varying the conductivity of said modulator in accordance with a signal.

4. A pulse regenerative oscillator comprising an electron discharge device having a cathode, and anode and a control grid, separate coils in circuit with said anode and grid which are coupled to each other, a line of predetermined length connected at one end between said cathode and ground and terminated at its other end such that a voltage wave traveling down the line from the cathode end will be reflected from said other end in-phase to produce a resultant voltage on said line effectively substantially double the initial voltage wave, an electron discharge modulator device whose anode current is substantially independent of anode potential coupled across said line, and means for applying audio frequency modulating potentials to said modulator to vary the conductivity thereof in accordance with a signal to be transmitted.

5. A pulse regenerative oscillator comprising an electron discharge device having a cathode, an anode and a control grid, separate coils in circuit with said anode and grid which are coupled to each other, a line of predetermined length connected at one end between said cathode and ground and terminated at its other end such that a voltage wave traveling down the line from the cathode end will be reflected from said other end in-phase to produce a resultant voltage on said line effectively substantially double the initial voltage wave, a source of anode polarizing potential for the anode of said device, a modulator in the form of a screen grid electron discharge device coupled across said line, means for applying modulating potentials to said modulator, and a connection from the screen grid of said modulator device to said source to vary the screen potential in phase with the voltage fluctuations of said source, said connection including at least one resistor.

6. A pulse regenerative oscillator comprising an electron discharge device having a cathode, an anode and a control grid, separate coils in circuit with said anode and grid which are coupled to each other, a line of predetermined length connected at one end between said cathode and ground and terminated at its other end such that a voltage wave traveling down the line from the cathode end will be reflected from said other end in-phase to produce a resultant voltage on said line effectively substantially double the initial voltage wave, a source of anode polarizing potential for the anode of said device, a modulator in the form of a screen grid electron discharge device coupled across said line, a condenser for by-passing the pulse frequency coupled between the screen grid of said last device and ground, means for applying modulating potentials to said modulator, and a connection from said screen grid to said source to vary the screen potential in phase with the voltage fluctuations of said source, said connection including a series resistor-shunt condenser arrangement, the time constant of said arrangement being equal to the time constant of said screen grid by-pass condenser and screen grid to ground resistance.

7. A pulse regenerative oscillator comprising an electron discharge device having a cathode, an anode and a control grid, separate coils in circuit with said anode and grid which are coupled to each other, a line of predetermined length connected at one end between said cathode and ground and terminated at its other end such that a voltage wave traveling down the line from the cathode end will be reflected from said other end in-phase to produce a resultant voltage on said line effectively substantially double the initial voltage wave, another coil coupled to said first coils for deriving the output from said pulse oscillator, and an ultra high frequency oscillator coupled to said other coil and responsive to the pulses therein for producing pulses of ultra high frequency energy.

8. A pulse regenerative oscillator comprising an electron discharge device having a cathode, an anode and a control grid, separate coils in circuit with said anode and grid which are coupled to each other, and a line of predetermined length connected at one end between said cathode and ground and terminated at its other end such that a voltage wave traveling down the line from the cathode end will be reflected from said other end in-phase to produce a resultant voltage on said line which is appreciably greater than the initial voltage wave, as a consequence of which the capacity of said line is charged to the value of said resultant voltage, and means for varying the rate of dissipation of the voltage charge on said line in accordance with a signal.

9. A pulse regenerative oscillator comprising an electron discharge device having a cathode, an anode and a control grid, separate coils in cir-

cuit with said anode and grid which are coupled to each other, and an artificial line of predetermined electrical length connected at one end between said cathode and ground and terminated at its other end such that a voltage wave traveling down the line from the cathode end will be reflected from said other end in-phase to produce a resultant voltage on said line appreciably greater than the initial voltage wave.

10. A pulse regenerative oscillator comprising an electron discharge device having a cathode, an anode and a control grid, separate coils in circuit with said anode and grid which are coupled to each other, a line of predetermined length connected at one end between said cathode and ground and terminated at its other end such that a voltage wave traveling down the line from the cathode end will be reflected from said other end in-phase to produce a resultant voltage on said line appreciably greater than the initial voltage wave, a modulator coupled across said other end of said line, and means for varying the conductivity of said modulator in accordance with a signal.

11. A pulse regenerative oscillator comprising an evacuated electron discharge device having a cathode, an anode and a control grid, separate coils in circuit with said anode and grid and which are coupled to each other, means for determining the duration of the pulse to be generated including a line of predetermined electrical length coupled at one end to an electrode of said device and terminated at its other end in such manner that a voltage wave traveling down the line from said electrode end will be reflected from the other end in such phase that the flow of current in said device will be extinguished when said reflected wave arrives at said electrode.

12. A pulse regenerative oscillator comprising an evacuated electron discharge device having a cathode, an anode and a control grid, separate coils in circuit with said anode and grid and which are coupled to each other, and means for determining the duration of the pulse to be generated including a line of predetermined electrical length coupled at one end to said cathode of said device and terminated at its other end in such manner that a voltage wave traveling down the line from the cathode end will be reflected from the other end in such phase that the flow of current in said device will be extinguished when said reflected wave arrives at said cathode.

13. A pulse oscillator comprising an electron discharge device having a cathode, means in circuit with said oscillator for causing said oscillator to produce recurring pulses of electrical energy, said means including a line of predetermined length connected at one end between said cathode and ground and terminated at its other end in a relatively high impedance compared to the characteristic impedance of the line such that a voltage wave traveling down the line from the cathode end will be reflected from said other end in-phase to produce a resultant voltage on said line appreciably greater than the initial voltage wave.

14. A pulse regenerative oscillator comprising an electron discharge device having a cathode, an anode and a control grid, separate coils in circuit with said anode and grid which are coupled to each other, and a low pass filter in the form of an artificial line of predetermined electrical length connected at one end between said cathode and ground and terminated at its other end by an impedance which is high compared to the characteristic impedance of said line such that a voltage wave traveling down the line from the cathode end will be reflected from said other end in-phase to produce a resultant voltage on said line appreciably greater than the initial voltage wave.

15. A pulse regenerative oscillator comprising an electron discharge device having a cathode, an anode and a control grid, separate coils in circuit with said anode and grid which are coupled to each other, a line of predetermined length connected at one end between said cathode and ground and terminated at its other end such that a voltage wave traveling down the line from the cathode end will be reflected from said other end in-phase to produce a resultant voltage on said line appreciably greater than the initial voltage wave, a modulator coupled across said other end of said line and having an internal plate impedance which is high compared to the characteristic impedance of said line, and means for varying the conductivity of said modulator in accordance with a signal.

16. A pulse regenerative oscillator comprising an electron discharge device having a cathode, an anode and a control grid, separate coils in circuit with said anode and grid which are coupled to each other, a line of predetermined length connected at one end between said cathode and ground and having a high impedance at its other end such that a voltage wave traveling down the line from the cathode end will be reflected from said other end in-phase to produce a resultant voltage on said line appreciably greater than the initial voltage wave, a modulator coupled across said line and having an internal plate impedance which is high compared to the characteristic impedance of said line, and means for varying the conductivity of said modulator in accordance with a signal.

17. A pulse oscillator comprising an electron discharge device having a cathode, a line of predetermined length connected at one end between said cathode and ground and having a high impedance at its other end such that a voltage wave traveling down the line from the cathode end will be reflected from said other end in-phase to produce a resultant voltage on said line appreciably greater than the initial voltage wave, a modulator coupled across said line and having an internal plate impedance which is high compared to the characteristic impedance of said line, and means for varying the conductivity of said modulator in accordance with a signal.

18. A pulse oscillator comprising an electron discharge device having a cathode, a line of predetermined length connected at one end between said cathode and ground and being open at its other end such that a voltage wave traveling down the line from the cathode end will be reflected from said other end in-phase to produce a resultant voltage on said line appreciably greater than the initial voltage wave, a vacuum tube coupled across said line and having an internal plate impedance which is high compared to the characteristic impedance of said line, and means for varying the conductivity of said vacuum tube in accordance with a signal.

19. In combination with an electron discharge device magnetron having a cathode, a surrounding anode structure, means for producing a magnetic field parallel to said cathode, a connection from said anode to ground, a pulse oscillator supplying said cathode with recurring rectangular wave form pulses of positive polarity and equal duration and of steep starting and trailing edges,

said pulses having a magnitude sufficient to cause said magnetron to produce correspondingly positioned pulses of high frequency energy solely during the time intervals of said pulses, and an electron discharge device modulator coupled to said pulse oscillator for varying the spacing between the equal duration pulses supplied to said magnetron in accordance with modulating potentials.

20. In combination with an electron discharge device magnetron having a cathode electrode and a surrounding anode electrode, means for producing a magnetic field parallel to said cathode, a connection from one of said electrodes to ground, a pulse oscillator supplying said other electrode with recurring rectangular wave form pulses of positive polarity and equal duration and of steep starting and trailing edges, said pulses having a magnitude sufficient to cause said magnetron to produce correspondingly positioned pulses of high frequency energy solely during the time intervals of said pulses, and an electron discharge device modulator coupled to said pulse

oscillator for varying the spacing between the equal duration pulses supplied to said magnetron in accordance with modulating potentials.

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