

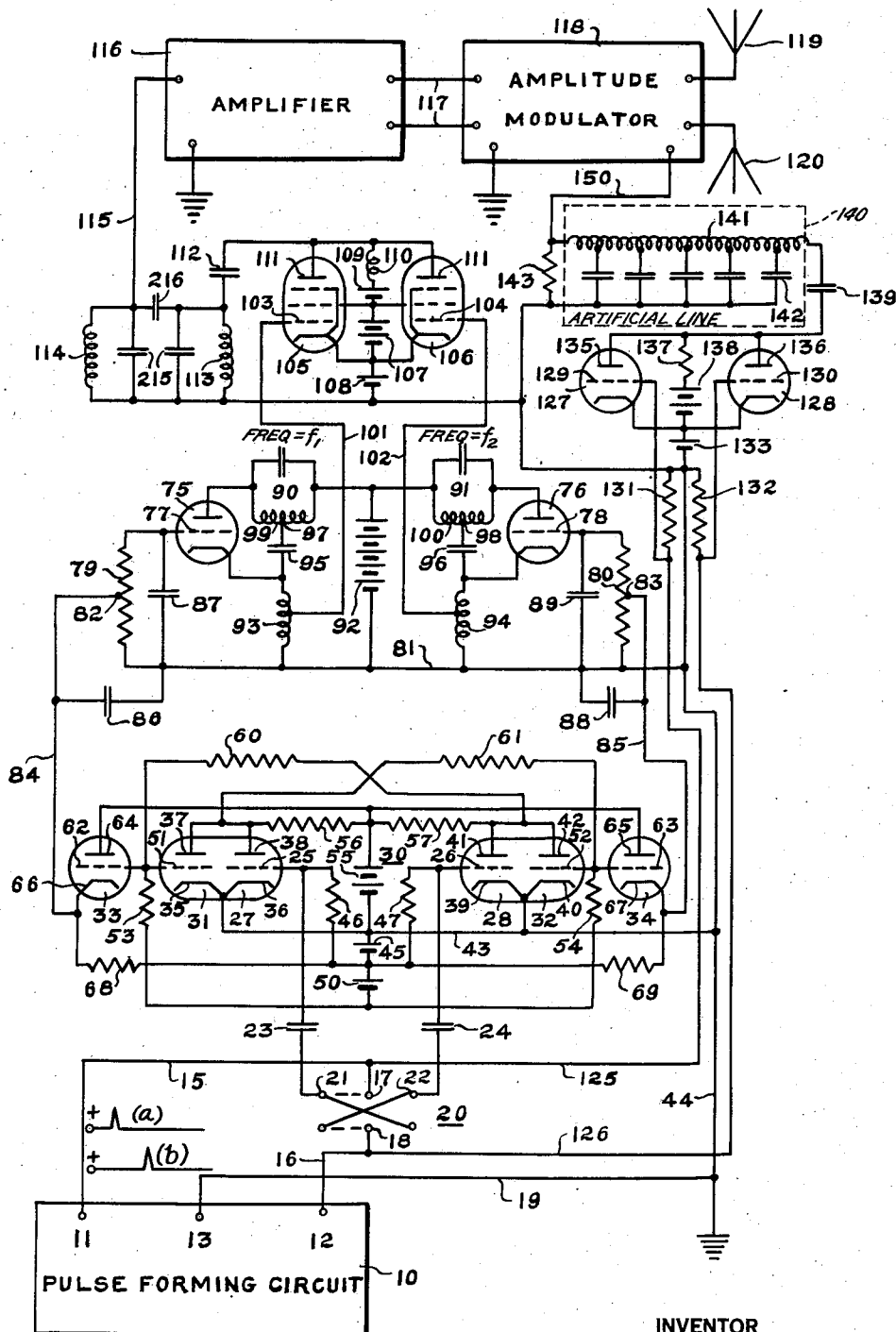
Aug. 30, 1949.

E. S. PURINGTON

2,480,338

RADIO CONTROL SYSTEM

Filed July 7, 1944



INVENTOR
ELLISON S. PURINGTON.
BY *[Signature]*
ATTORNEY

UNITED STATES PATENT OFFICE

2,480,338

RADIO CONTROL SYSTEM

Ellison S. Purington, Gloucester, Mass., assignor,
by mesne assignments, to Radio Corporation of
America, New York, N. Y., a corporation of
Delaware

Application July 7, 1944, Serial No. 543,918

11 Claims. (Cl. 250-17)

1

This invention relates to a radio control system of the type utilizing a pair of transmission channels which are selectively pulsed in timed sequence, and has for an object to provide a system of the above type utilizing a single transmitter which is modulated to propagate pulses alternately and in timed sequence on the respective channels.

Other objects and advantages will be apparent as the nature of the invention is more fully disclosed.

In a copending application Ser. 536,104, filed May 18, 1944, now U. S. Patent No. 2,465,925, granted March 29, 1949, a complete system for radio control or signalling has been disclosed involving two independent radio transmitters with the sense of control or signal determined by the pulse sequence. A receiver is selective to the various pulse sequences for actuating selected control or signal circuits. The present invention relates to a transmitter having novel and improved characteristics for use in a system of the above type.

Although the novel features which are believed to be characteristic of this invention are pointed out more particularly in the claims appended hereto, the invention itself will be better understood by referring to the following description, taken in connection with the accompanying drawings, in which a specific embodiment thereof has been set forth for the purposes of illustration.

In the drawings: The figure is a schematic diagram of a transmitter embodying the present invention.

Referring to the drawings, block 10 represents a pulse forming circuit having pulse output terminals 11 and 12 and a common return connected to a terminal 13. The pulse forming circuit is adapted to form a pulse *a* at the terminal 11 followed by a similar pulse *b* at the terminal 12, the pulses *a* and *b* being positive voltage pulses with respect to the common return or ground terminal 13. The arrangement is such that, except when a pulse occurs, the terminals 11 and 12 are at ground potential. The pulse momentarily raises the terminal 11 above ground potential and then momentarily raises the terminal 12 above ground potential. One type of circuit suited for producing such pulses at the terminals 11, 12 and 13 is shown more in detail in the co-pending application above mentioned.

The output terminals 11 and 12 of the pulse forming circuit are connected by lines 15 and 15' to movable contacts 17 and 18 respectively of a reversing switch 20. The return terminal 13 is connected to a grounded line 19.

2

The reversing switch 20 is provided with stationary contacts 21 and 22 which are connected through condensers 23 and 24 respectively to the input grids 25 and 26 of two pulsing triodes 27 and 28 of a "flip-flop" circuit 30.

This circuit 30 includes the pulsing triodes 27 and 28, holding triodes 31 and 32 and following triodes 33 and 34. The cathodes 35 and 36 and the plates 37 and 38 of the triodes 27 and 31, which may be contained in the same envelope, are shown as connected together. Similarly cathodes 39 and 40 and plates 41 and 42 of the triodes 28 and 32, which may be mounted in the same envelope, are shown as connected together. The cathodes 35, 36, 39 and 40 are connected by a line 43 to a grounded line 44. A source of negative grid bias, shown as a battery 45, is connected through resistors 46 and 47 to the grids 25 and 26 of the triodes 27 and 28 respectively. Battery 45, and a battery 50 connected in series therewith, furnish negative grid bias to the grids 51 and 52 of the triodes 31 and 32 through the resistors 53 and 54 respectively. A source of plate potential, shown as a battery 55, is connected through resistors 56 and 57 to supply plate voltage to the anodes 37 and 38 and to the anodes 41 and 42 respectively. The negative potential supplied by the source 45 is so chosen that in the absence of a pulse from the pulse forming circuit 10 no current passes through either the triode 27 or the triode 28.

The anodes 41 and 42 are connected through a resistor 60 to the grid 51 of the triode 31 and the anodes 37 and 38 are connected through a resistor 61 to the grid 52 of the triode 32. The triodes 33 and 34 are provided with grids 62 and 63 which are connected to the grids 51 and 52 respectively and anodes 64 and 65 which are connected to the positive voltage source 55. Cathodes 66 and 67 of triodes 33 and 34 are connected through resistors 68 and 69 respectively to the source of biasing voltage 45.

In this circuit the tubes 31 and 32 are cross-connected by direct coupling from the plate of each to the grid of the other. Such a system possesses two positions of stable equilibrium in which one of the tubes draws a large amount of plate current with a small bias on its grid and the other draws a small amount of plate current with a large bias on its grid. The circuit constants may be so chosen that each of the tubes 31 and 32 draws current only when its grid is at substantially cathode potential.

For example, prior to the arrival of the pulses the tube 32 may be assumed to be passing current,

3

thereby producing a voltage drop through the resistor 57 which reduces the voltage on the anodes 41 and 42. Due to the direct coupling through the resistor 60 to the grid 51 of the tube 31 a highly negative bias is supplied to the grid 51 which biases the tube 31 beyond cut-off so that no current flows therethrough or through its plate resistor 56. Since no current flows through the resistor 56 the anodes 37 and 38 are substantially of the potential of the positive terminal of the source 55 and due to the direct coupling through the resistor 61 to the grid 52 the latter is at a higher potential than the grid 51, for example, at cathode potential.

This condition of voltage and current will continue until influenced by the operation of the pulsing of tube 27. When a momentary pulse is applied to the grid 25 of this tube as by a pulse received through line 15 from a terminal 11, the tube 27 becomes conductive and plate current is caused to flow through the resistor 56, causing a voltage drop in this resistor which, due to the direct coupling through the resistor 61 to the grid 52 of the tube 32, increases the negative bias of the grid 52 beyond cutoff so that current flow through the resistor 57 is interrupted. This, in turn, causes an increase in potential of the anodes 41 and 42, which is applied through the resistor 60 to the grid 51 of the tube 31 to increase the potential of the grid 51 and cause the tube 31 to pass current. After the pulse on the input of the tube 27 has passed, the tube 27 will again become non-conductive, but the tube 31 will continue to pass current. Hence, the current through the resistor 56 will decrease somewhat but insufficiently to cause the tube 32 to pass current. Therefore, the tube 31 continues to pass plate current with its grid biased near cathode potential.

Hence, as a result of a momentary pulse on the tube 27, the tube 32 which was previously conducting becomes non-conducting, and the tube 31 which was previously non-conducting becomes conducting. This state of stability will hold until a pulse is applied to the grid 26 of the tube 28 from the terminal 12 which momentarily causes the tube 28 to become conducting and through a process similar to that above described changes the biasing voltages on the tubes 31 and 32 so that the tube 31 becomes non-conducting and tube 32 becomes conducting.

As a result of the above operation, the grid 51 of the tube 31 remains highly negative except during the interval between the pulses *a* and *b* at the terminals 11 and 12, but during this interval the voltage of the grid 51 rises. Similarly, the voltage of the grid 52 of the tube 32 is highly negative during the period between the pulses *a* and *b*, but rises outside of this period. Therefore, the circuit establishes two oppositely phased pulses at the grids 51 and 52 with the length of the pulses equal to the time interval between the two control pulses.

The triodes 33 and 34 are cathode following tubes or repeater tubes provided with plates 64 and 65 connected to the positive end of the source 55 and with cathodes 66 and 67 normally negatively biased through the resistors 68 and 69. The tubes serve as repeaters of the impressed grid voltage without phase reversal and are desirable to prevent the subsequent work circuits from disturbing the action of the flip-flop circuit 30.

Two grid-modulated high frequency oscillators 75 and 76 are designed to produce output voltages of frequencies f_1 and f_2 respectively. The oscillators 75 and 76 are provided with grids 77 and

4

78 connected through resistors 79 and 80 to a ground lead 81. Taps 82 and 83 on resistors 79 and 80 are connected by lines 84 and 85 to the cathodes 66 and 67 of the tubes 33 and 34 respectively. The resistors 79 and 80 may be by-passed to ground by condensers 86 to 89.

The plates of the triode oscillator tubes 75 and 76 are connected through oscillatory circuits 90 and 91 respectively to the positive end of a plate battery 92, the negative end of which is grounded to the lead 81. Tapped inductors 93 and 94 are connected from the cathodes of the triodes 75 and 76 to ground and low impedance condensers 95 and 96 are connected from the cathodes to taps 97 and 98 on inductors 99 and 100 for transferring of alternating voltages from oscillator circuits 90 and 91 respectively to the cathodes.

After the arrival of the pulse *b* and before the arrival of the next pulse, the oscillator 76 is in oscillation but the tube 75 is not oscillating since its grid circuit is biased negative to cut off by the cathode 66 of the tube 33. Upon the arrival of the pulse *a* with the consequent reversal in grid potentials in the tubes 33 and 34, the grid of the tube 76 is caused to become highly negative, thereby stopping that tube from oscillating whereas the grid of the tube 75 is raised in potential to permit that tube to begin oscillating. This condition holds until the next pulse *b* is received at the terminal 12 which reverses the action and causes the tube 75 to stop oscillating and the tube 76 to begin oscillating. Therefore a voltage of frequency f_2 is produced across the inductor 94 during the interval between pulse *b* and the next pulse *a* and a voltage of frequency f_1 is produced across the inductor 93 during the period between the pulse *a* and the pulse *b*.

These voltages f_1 and f_2 are applied by lines 101 and 102 respectively to the control grids 103 and 104 of pentodes 105 and 106 which are connected to constitute a combining circuit. The cathodes of the pentodes 105 and 106 are connected together and are positively biased by battery 108. The screens of the pentodes 105 and 106 are connected together and are positively biased by battery 107, and the plates are fed from the positive end of a battery 109 through a choke 110.

The plates 111 are connected through a low impedance condenser 112 to a coupled circuit network comprising inductances 113 and 114 and condensers 215 and 216 which are designed to have maximum frequencies of response at the frequencies f_1 and f_2 . These frequencies may, if desired, be separated widely on a percentage basis with, for example, frequency f_2 50% higher than frequency f_1 . The details of construction of such a coupled circuit network per se are well known and need not be described herein.

In the embodiment shown, the network is connected by a line 115 to an amplifier 116 of any standard design which is capable of amplifying the two frequencies f_1 and f_2 . The amplifier 116 is coupled by lines 117 to an amplitude modulating circuit 118 of standard construction, which in turn is connected to radiators 119 and 120 which are suited to radiate waves of frequencies f_1 and f_2 .

The terminals 17 and 18 of the double throw switch 20 are also connected by lines 125 and 126 to the input circuits of space discharge tubes 127 and 128 respectively having grids 129 and 130 which are grounded through resistors 131 and 132. A battery 133 is shown as connected to supply grid biasing potentials. The devices 127 and 128 are also provided with plates 135 and 136 connected

through a resistor 137 to a source of plate potential 138 and through a condenser 139 to an artificial line 140 comprising series inductors 141 and shunt condensers 142 and terminated in an output resistor 143. The voltage drop across the resistor 143 is supplied by a line 150 to the amplitude modulator 118.

The pulses from terminals 11 and 12 are combined in the plate circuits of the tubes 127 and 128 and pass to the artificial transmission line 140 in succession to produce negative voltage pulses across the resistor 143 which are used to amplitude modulate the signal from the amplifier 116. The pulses are delayed by the artificial transmission line 140 an amount such that the pulses do not arrive at the modulator during periods of change over from frequency f_1 to frequency f_2 and vice versa. Hence the pulse a will modulate the transmitter when it is operating at the frequency f_1 and the pulse b will modulate the transmitter when it is operating at the frequency f_2 .

The transmitter is preferably of the type which takes plate current only when negatively pulsed, during which time it propagates from the antenna system 119, 120 whichever of the two frequencies is then impressed upon the amplifier 116 from line 115. With the reversing switch 20 in one position, the transmitter will radiate on the frequency f_1 when modulated by the pulse a and on frequency f_2 when modulated by the pulse b . With the reversing switch 20 in the opposite position the transmitter will radiate on the frequency f_2 when modulated by the pulse a and on the frequency f_1 when modulated by the pulse b . The reversing switch accordingly determines the sequence of the pulses on the two frequencies.

As pointed out in the co-pending application above identified, the selected pulse sequence may be utilized for selectively energizing control circuits at a receiver so that one type of control is produced with the reversing switch in one position and another type of control is produced with the reversing switch in the opposite position. The transmitter is thus frequency modulated to selectively operate on frequencies f_1 and f_2 and is also amplitude modulated by pulses a and b in accordance with the timing of said pulses.

Although a specific embodiment of the invention has been shown for purpose of illustration, it is to be understood that various changes and adaptations may be made as will be readily apparent to a person skilled in the art. The invention is only to be restricted in accordance with the scope of the following claims.

What is claimed is:

1. A radio signalling system comprising radio transmitting means including a source of signalling energy and a radiator connected to propagate said energy, a source of a series of energy pulses having a predetermined time sequence, means modulating the frequency of said transmitting means in response to successive pulses to cause said transmitting means to operate alternately to propagate energy over a pair of different frequency channels, means modulating the amplitude of the transmitted energy by said pulses including timed means to cause alternate pulses to be radiated on different frequency channels, and means controlling the sequence of said pulses with respect to said channels.

2. A radio signalling system comprising radio transmitting means and a radiator connected thereto to propagate radiant energy waves, a source of a series of energy pulses having a pre-

determined time sequence, means responsive to said pulses to modulate said transmitting means both in frequency and in amplitude in a manner to propagate alternate pulses on different frequency channels, and means controlling the sequence of said pulses with respect to said channels.

3. A radio signalling system comprising radio transmitting means including sources of oscillations of different frequencies, a source of a series of energy pulses having a predetermined time sequence, means responsive to successive energy pulses to render said oscillation sources alternatively operative, additional means responsive to said energy pulses for modulating the amplitude of said oscillations in a manner such that alternate pulses are radiated over different frequency channels, and means controlling the sequence of said pulses with respect to said channels.

4. A radio signalling system comprising a pair of oscillators connected to operate respectively at different frequencies, a source of a series of energy pulses having a predetermined time sequence, means responsive to successive pulses for alternately energizing the respective oscillators, a transmission channel, means supplying oscillations from said oscillators thereto during successive periods, means responsive to said pulses, including pulse delaying means, arranged to amplitude modulate said channel during said successive periods, and means controlling the sequence of said pulses with respect to said frequency periods.

5. A radio signalling system comprising a source of a series of energy pulses having a predetermined time sequence, a pair of space discharge devices connected to be energized alternately by successive pulses, means causing each of said devices when energized to continue to pass current until deenergized by the succeeding energy pulse, a pair of oscillators operating at different frequencies, means responsive to passage of current by said last devices to cause said oscillators to operate alternately during the respective periods, a transmission channel receiving said oscillations, and means connected to amplitude modulate said channel in accordance with said pulses so that successive pulses modulate said channel when the latter is operating at different frequencies.

6. A radio signalling system comprising a source of a series of energy pulses having a predetermined time sequence, a pair of space discharge devices connected to be energized alternately by successive pulses, means causing each of said devices when energized to continue to pass current until deenergized by the succeeding energy pulse, a pair of oscillators operating at different frequencies, means responsive to passage of current by said last devices to cause said oscillators to operate alternately during the respective periods, a transmission channel receiving said oscillations, and means connected to amplitude modulate said channel in accordance with said pulses, said last means including a delay circuit connected to delay said amplitude modulation pulses to coincide with the different frequency periods of said channel so that successive pulses modulate said channel when the latter is operating at different frequencies.

7. A radio signalling system comprising a source of a series of energy pulses having a predetermined time sequence, a pair of space discharge devices connected to be energized alternately by successive pulses, means causing each of said devices when energized to continue to pass current

until deenergized by the succeeding energy pulse, a pair of oscillators operating at different frequencies, means responsive to passage of current by said last devices to cause said oscillators to operate alternately during the respective periods, a transmission channel receiving said oscillations, means connected to amplitude modulate said channel in accordance with said pulses, said last means including a delay circuit connected to delay said amplitude modulation pulses to coincide with the different frequency periods of said channel so that successive pulses modulate said channel when the latter is operating at different frequencies, and means controlling the sequence of said pulses with respect to said frequency periods.

8. A radio signalling system comprising a source of a series of energy pulses having a predetermined time sequence, a pair of space discharge devices connected to be energized alternately by successive pulses, means causing each of said devices when energized to continue to pass current until deenergized by the succeeding energy pulse, a pair of oscillators operating at different frequencies, means responsive to passage of current by said last devices to cause said oscillators to operate alternately during the respective periods, a transmission channel receiving said oscillations, means connected to amplitude modulate said channel in accordance with said pulses, said last means including a delay circuit connected to delay said amplitude modulation pulses to coincide with the different frequency periods of said channel so that successive pulses modulate said channel when the latter is operating at different frequencies and a reversing switch connected to control the sequence of said pulses with respect to said frequency periods.

9. In radio signalling apparatus, a source of recurring energy pulses separated by like time intervals, a transmitter, oscillatory energy generating apparatus coupled to said transmitter and controlled by said pulses to supply to said transmitter pulses of energy the frequency of which alternates from a first frequency to a second frequency, sending means connected with said transmitter, an amplitude modulator in said transmitter, connections for impressing said pulses from said first mentioned source on said amplitude modulator, and a time delay network in said last named connections.

10. In radio signalling apparatus, a source of recurring energy pulses separated by like time intervals and having a predetermined time sequence, a transmitter, oscillatory energy generating apparatus coupled to said transmitter and controlled by said pulses to supply to said transmitter pulses of energy the frequency of which alternates from a first frequency to a second frequency, signal sending means connected with said transmitter, an amplitude modulator in said transmitter, couplings for impressing said pulses from said first mentioned source on said amplitude modulator, a time delay network in said last named connections and a pulse sequence reversing switch in the coupling between said first source and said apparatus and said first source and said modulator.

11. In radio signalling apparatus, a source of energy pulses separated by like time intervals and having a predetermined time sequence, a transmitter, oscillatory energy generating apparatus coupled to said transmitter, a switching circuit including two tubes coupled to said apparatus and coupled to said first source to be alternately conductive in response to said pulses to key said generating apparatus and produce oscillatory energy the frequency of which alternates from a first frequency to a second frequency, signal sending means connected with said transmitter, an amplitude modulator in said transmitter, connections for impressing said pulses from said first mentioned source on said amplitude modulator and a time delay network in said last named connections.

ELLISON S. PURINGTON.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,181,568	Kotowski et al.	Nov. 28, 1939
2,282,102	Tunick	May, 5, 1942
2,376,395	Skellet	May 22, 1945

FOREIGN PATENTS

Number	Country	Date
540,233	Great Britain	Oct. 9, 1941