Aug. 10, 1948. G. W. FYLER 2,446,819

SYNCHRONIZED PULSE COMMUNICATION SYSTEM

Filed March 27, 1943

Fig. 1.

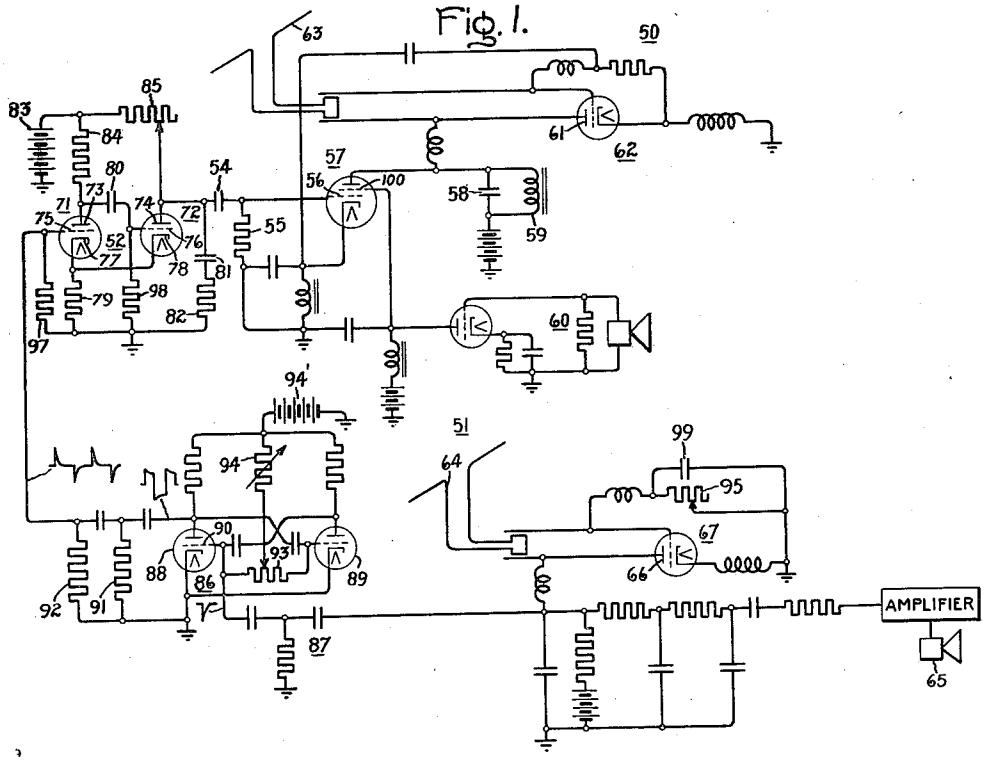


Fig. 2.

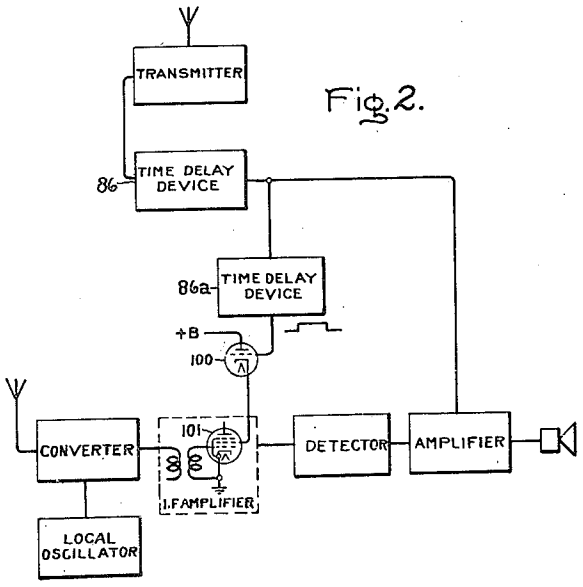
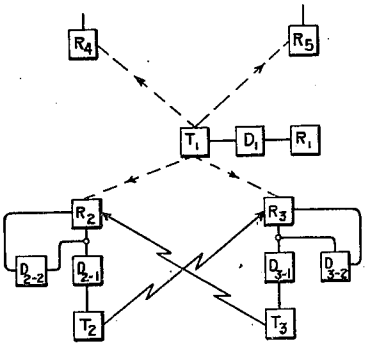


Fig. 3.



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Patented Aug. 10, 1948 2,446,819

UNITED STATES PATENT OFFICE

2,446,819

SYNCHRONIZED PULSE COMMUNICATION SYSTEM

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Application March 27, 1943, Serial No. 480,823

6 Claims. (Cl. 250—13)

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My invention relates to pulse systems of communication.

Pulse systems are advantageous for the transmission of speech, music, and other forms of intelligence, because the effect of extraneous electric fields, noise, etc., which may affect the receiving apparatus, may be reduced by rendering the receiving means inoperative during the intervals between pulses. Moreover, by width or frequency modulating the pulses of radio frequency carrier, limiting means may be employed to eliminate, or at least substantially reduce, the amount of noise voltage appearing on the received pulses. Moreover, for a given average power, it is possible to operate the transmitting oscillator electron discharge devices or tubes at high instantaneous powers and, consequently, high efficiencies. It is therefore, an object of my invention to provide a new and improved radio communication system of the pulse type.

Another object of my invention is to provide a new and improved method and means for reception in which the effects of undesired impulses, extraneous influences, etc. are reduced or eliminated.

The utilization of pulse communication systems makes possible duplex or multiplex operation on one frequency whereby two or more different conversations or transmissions of signals may be conducted on one frequency at the same time without interference. It is another object of my invention to provide a new and improved system for duplex or multiplex operation.

It is still another object of my invention to provide a duplex or multiplex system in which impulses may be transmitted only when no signal is being received.

Another object of my invention is to provide in duplex or multiplex systems, means for synchronizing the times of transmission of the various transmitting means.

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 drawing in which Fig. 1 represents schematically a circuit embodying the principles of my invention; Fig. 2 shows a modified form of receiver which may be substituted for the receiver shown in Fig. 1; and Fig. 3 shows in block form an adaptation of the principles of my invention to a multiplex system of radio communication.

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In Fig. 1, there is shown an embodiment of my invention permitting duplex or multiplex communication on a single band of frequencies. Means is provided whereby pulses are transmitted only during the intervals between received pulses.

At each station in the system, there is provided a suitable transmitter 50 and a suitable receiver 51.

The transmitter may comprise a sawtooth wave generator 52, illustrated in the form of a multivibrator of the floating cathode type, and may comprise electron discharge devices 71 and 72 having anodes 73, 74, control electrodes 75, 76 and the cathodes 77, 78, respectively. A cathode biasing resistor 79 is provided between the cathodes and ground. The capacitor 80 is connected between the anode 73 and the control electrode 76. A capacitor 81 and a resistor 82 are connected in series between the anode 74 and ground. The control electrodes are connected to ground by suitable resistors 97 and 98. Anode potential is obtained from a source 83, the positive terminal of which is connected to the anode 73 through a resistance 84 and to the anode 74 through a variable resistance 85. The circuit constants are arranged so that discharge device 71 is conductive over substantially the entire pulse cycle. When the discharge device 71 begins to conduct, the anode potential of anode 73 becomes less and the charge on condenser 80 causes control electrode 76 to become negative and the discharge device 72 is rendered non-conductive. The capacitor 81 tends to become charged when the device 72 is non-conductive because of the high potential then existing on anode 74. The charge on capacitor 80, which accumulated during the preceding interval tends to leak off through the resistance 98 and the control electrode 76 gradually becomes less negative and finally becomes sufficiently less negative to permit the device 72 to conduct current. Such conduction causes current to flow through the resistance 79 and drives the cathode 77 slightly more positive with respect to the control electrode 75 and thereby causes a reduction of the anode current through the device 71. The result is an increase in the positive potential on the anode 73 which drives the control electrode 76 of the device 74 slightly more positive to increase the current through the discharge device 72. The current in the resistance 79 again increases. This increase continues until the discharge device 71 is cut off. The condenser 81

is discharged when the device 72 becomes conductive. By the proper choice of circuit constants the output voltage is sawtooth in shape because of the intermittent charge and discharge of the condenser 81.

The sawtooth waves are impressed upon the control electrode 56 of an electron discharge device 57. The output from the discharge device 57 is impressed across a capacitor 58 and an iron core inductance 59. The inductance permits the storage of energy during the slow rise of the sawtooth wave. Upon termination of the rise of the sawtooth wave, the stored energy is released suddenly by the condenser 58 and the inductance 59 at a relatively high potential to the anode 61 of the oscillator 62. The sudden release provides a pulse of high intensity, short duration, radio frequency energy which is transmitted over the antenna 63 to the remote receiver. Suitable modulation means may be employed as indicated by the numeral 60. The amplitude of the sawtooth wave of plate current in the discharge device 57 may be controlled or varied by the potential of a second control electrode 100 of the device 57. The discharge of the device 57 is dependent not only on the waves impressed thereon by means of the control electrode 56 but also by the potential of the second control electrode 100. In this manner a simple modulator of the Heising type may be used for modulating the potential of the control electrode 100 in accordance with audio modulation frequencies. It is apparent that the pulse rate should be higher than the highest modulating frequency.

The lower portion of Fig. 1 illustrates a suitable periodically apertured receiver which may be of the super-regenerative type with a self-quench rate which is nearly the same as the repetition rate of the multi-vibrator. Signals received on the antenna 64 are reproduced by any desired means including a loudspeaker 65.

Means is provided to synchronize the transmission and reception of pulses from any one station so that pulses are not transmitted during the period of reception of pulses. This means may comprise a suitable time delay device 86 connected between the anode 66 of the detector 67 and the control element 75 of the discharge device 71 of the sawtooth wave generator. A negative impulse appearing on the anode 66 of the detector is differentiated in a suitable filter 87 to remove audio components of the anode voltage and is impressed on the time delay circuit 86. The time delay circuit illustrated is in the form of a multivibrator, and includes electron discharge devices 88 and 89. The differentiated pulses from the receiver are impressed on the control electrode 90 of device 88. Relatively square pulses appear in the anode circuit as indicated in the drawing. These pulses are differentiated in suitable filter sections 91 and 92 and the sharp, differentiated pulses, the shape of which is indicated at the output of the filter sections, are impressed on the control electrode 75 of the discharge device 71 in the sawtooth wave generator of the transmitter.

Inasmuch as the discharge device 71 is normally conducting, the appearance of positive pulses on the control electrode usually has no effect and the generator continues to generate sawtooth waves. However, the receipt of negative pulses drives the control electrode 75 sufficiently negative to cut off the discharge device 71 and interrupt the production of sawtooth waves by causing discharge device 72 to discharge condenser 81. Thus, it may be considered that the transmitter is rendered inoperative when pulses are to be received or that the transmitter is rendered operative for the transmission of pulses only at predetermined times between the receipt of pulses from a remote transmitter.

In order to adjust the time interval between the positive and negative impulses impressed on the control electrode 75 there is provided means 93 comprising a potentiometer type resistance connected between the control electrodes of the devices 88 and 89. This causes variation of the relative widths of the positive and negative square blocks without appreciably changing the frequency. If the repetition rate of pulses in the multivibrator 52 of the transmitter and the quench frequency of the receiver are chosen relatively close together, as, for example, 1000 cycles per second and 990 cycles per second respectively, the receiver and transmitter will tend to pull into synchronism in such a manner that the local transmitter will emit pulses at a definite time during the intervals between the receipt of pulses from the distant stations. Of course, these frequencies should normally be higher than the highest modulating frequency, as previously pointed out above. Therefore these values are merely illustrative. For voice communication purposes, these frequencies might be at least 5,000 to 10,000 cycles per second to insure good intelligibility.

In order to adjust the repetition rate of the sawtooth wave generator 52, the resistances 85 and 93 may be made variable. In a similar manner, in order to adjust the repetition rate of the multivibrator 86 in the time delay circuit associated with both the transmitter and the receiver, a resistance 94 of the variable type may be connected between the positive terminal of the source of potential 94' and a point on the potentiometer 93. The quench rate of the receiver may be adjusted to the desired frequency by providing a variable resistor 95 shunted by a suitable capacitance 99 in the grid-to-cathode circuit.

By proper choice of constants in the time delay circuits, the system automatically locks in such a way that the receiver synchronizes with the remote transmitter, and the local transmitter synchronizes with the local receiver by means of the time delay device. The remote receiver locks in with the local transmitter and the remote transmitter then synchronizes or locks in with the remote receiver.

The provision of the time delay circuits, and the adjustment device or means 93, enables adjustment of a given receiver and transmitter to any remote receiver and transmitter irrespective of the distance between the stations.

The above described system embodying the time delay devices 86 is particularly advantageous because if the synchronizing pulses at one of the receiving stations are too weak to cause locking of the transmitter, or if one of the locking or time delay means fails for any reason, proper operation of the system will take place because the transmitter in one station will synchronize the receiver at the distant station, the distant receiver will lock-in the distant transmitter and the local receiver will then lock in with the distant transmitter. In this way a double lock is provided which will insure proper operation of the system even if only one end of the system is working properly and, accordingly, the reliability of the system is appreciably increased.

It has been stated that a superheterodyne type

receiver may be used instead of the super-regenerative type previously described. In such a case, there is no quench rate to be synchronized with the received signal pulse. The use of a superheterodyne receiver instead of a super-regenerative detector, therefore, would ordinarily prevent any time selection of incoming pulses unless the receiver is automatically apertured into operation or rendered operative just before the desired pulse is received. Means for accomplishing this result is shown in Fig. 2. There is shown an arrangement whereby a second time delay device 86*a* is synchronized from the superheterodyne receiver output and the differentiated output pulse is used to raise the potential on a control electrode, such as a screen electrode of a discharge device 100. When device 100 becomes conductive, its cathode potential becomes relatively high and the screen grid potential of the discharge device 101 in the intermediate frequency stage becomes sufficiently high to aperture or render operative the receiver during the period when the desired synchronizing signal is received. The repetition rate of the delay device 86*a* as well as its delay control must be carefully adjusted for the desired incoming pulse in a manner similar to the system shown in Fig. 1. Different signals operated on the same carrier frequency but at different phase relations for a given pulse rate may be selected by adjustment of the repetition rate so that the synchronism can slip from one signal to another until the desired signal is received. In the case of narrow pulses and a narrow receiver aperture, little interference would be expected from non-synchronous signals.

More than two stations may be included in a network operating on a single band of frequencies with different delay settings. In such an arrangement it is only necessary that the time delay circuit in the various stations be adjusted to cause operation in the intervals between pulses from other stations operating on the same frequency. Each station will require certain intervals of reception due to each pulse period for each of the stations on the network, depending upon the delays at each transmitter as well as the various distances of transmission.

In Fig. 3 there is illustrated in a general way how such a system might be operated. Master transmitter T_1 sends out a reference pulse for synchronizing purposes to all receivers, and the signals are received by, for example, receiver R_2. A time delay device D_{2-1} at station R_2 is shown for synchronizing operation of the transmitter T_2 with the receiver R_2 and a second delay device D_{2-2} is used for opening up or gating the receiver just prior to the synchronizing pulse so that definite synchronization is obtained on the master station. Additional delay devices may be connected to receiver R_2 if it is desired to ungate or open up the receiver at another time in each period when a signal is received from transmitter T_3, for instance, the latter station also being synchronized with the main or master station. Communication can be carried on between any pair of remote stations or even between several pairs of remote stations at the same time, on the same frequency and at the same pulse rate, so long as a delay device is provided for each transmitter to be heard in each pulse period. The master station may be adjusted to hear any remote station and can break in on any conversation at will.

While I have shown and described a particular embodiment of my invention, it will be obvious to those skilled in the art that changes and modifications may be made without departing from my invention in its broader aspects, and I, therefore, aim in the appended claims to cover all such changes and 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 communication system including a plurality of spaced stations, a pulse generating transmitter at each of said stations, said transmitters generating and radiating discrete pulses at substantially the same repetition rate, a pulse receiver at each of said stations, means for synchronously rendering each of said receivers periodically operative to receive pulses from one of said transmitters, independently operating synchronizing means interposed between the receiver and transmitter at each station for controlling the transmitter pulse rate, said means comprising a pulse generator synchronized by said received pulses, means for adjusting the width of pulses developed by said generator, and means utilizing the trailing edges of said pulses to synchronize the transmitter at the same station, thereby to delay the transmission of pulses from the same station for adjustable periods within the intervals between said received pulses.

2. In a pulse communication system, a plurality of stations each including a pulse transmitter and a pulse receiver, a separate pulse generator for controlling each of said transmitters, means for rendering each of said receivers periodically operative to receive pulses thereby to synchronize each receiver with pulses received from any one of said other transmitters, and time element synchronizing means at each of said stations interposed between said receiver and said pulse generator, said synchronizing means comprising a second pulse generator adapted to be synchronized by said received pulses, and means for adjusting the time position of synchronizing pulses supplied from said second pulse generator to delay pulse transmission from any station with respect to pulse reception at the same station by a selectable amount so that radiation of pulses at any station is restricted to predetermined discrete intervals between pulse reception at the same station.

3. In a pulse communication system, a pair of spaced stations each including a pulse transmitter and a separate pulse receiver, a pair of pulse generators each having substantially the same free-running repetition rate and each arranged to control one of said transmitters, each of said receivers including means independent of received pulses for rendering said receiver periodically operative to receive pulses at substantially said repetition rate, each said receiver automatically synchronizing with pulses received from the other of said transmitters, adjustable time delay means at each station responsive to pulses received at the same station for developing synchronizing pulses recurring at the same rate as said received pulses but delayed by a selectable time interval, and means for synchronizing the pulse generator at the same station with said delayed pulses, thereby to render the transmitter at said same station operative to radiate pulses only in the intervals between said received pulses, said time delay intervals being adjusted to cause the transmitters and receivers at both said stations to be mutually locked in synchronism in a closed loop to operate at said repetition rate.

4. A pulse communication system comprising a pair of spaced stations, a pulse transmitter at

each station including a control pulse generator, each of said pulse generators having substantially the same free-running repetition rate, a super-regenerative receiver at each of said stations having a quench rate substantially equal to said predetermined repetition rate, each of said receivers automatically synchronizing with the other of said transmitters, and adjustable time delay means at each of said stations responsive to received pulses at the same station for developing synchronizing pulses recurring at said repetition rate but delayed by a selectable time interval, and means for synchronizing the pulse generator at the same station with said delayed pulses, thereby to insure that pulses are transmitted from each station only in the intervals between reception of pulses at the same station, said time delay intervals being adjusted to cause the transmitters and receivers at both said stations to be mutually locked in synchronism in a closed loop to operate at said repetition rate.

5. A pulse communication system comprising a plurality of variably spaced stations, a pulse transmitter at each station including a pulse generator, each said pulse generator having substantially the same predetermined repetition rate, a periodically operative receiver at each station apertured at a rate substantially equal to said repetition rate, each said receiver being arranged to synchronize with any one of said transmitters, a multivibrator at each of said stations connected for synchronization by pulses received at the same station, each said multivibrators being connected to synchronize the local pulse generator with pulses received at the local receiver so that pulses are transmitted from any station only at discrete intervals between received pulses, and means for varying the on-off ratio of said multivibrator thereby to vary the time interval between received and transmitted pulses at any one station in accordance with the spacing between said stations.

6. In a pulse communication system including

a pair of spaced stations, a pulse transmitter in each of said stations, a control pulse generator for causing each of said transmitters to radiate discrete pulses at the pulse frequency of said generator, each said generator being adapted to be synchronized for operation at a common pulse frequency, a pulse receiver in each of said stations, means for synchronizing each receiver with pulses from the transmitter at the other station and for rendering said receiver operative only during short time intervals including said pulses, and adjustable time delay means controlled by received pulses from each receiver for impressing synchronizing pulses on the control pulse generator at the same station after a selectable time delay, thereby to restrict radiation of pulses from each station to discrete intervals between reception of pulses at the same station, said time delays being adjusted to cause the transmitters and receivers at both said stations to be mutually locked in synchronism in a closed loop to operate at said common pulse frequency.

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