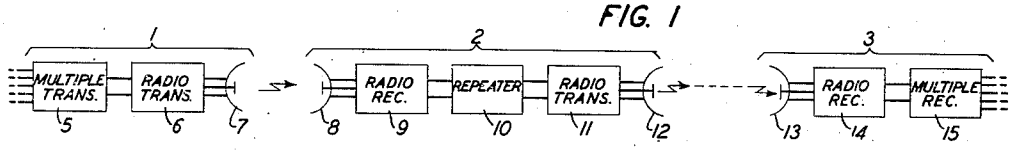
Dec. 28, 1948. G. H. HUBER 2,457,559

REPEATER FOR PULSE COMMUNICATION SYSTEM

Filed Feb. 15, 1945

FIG. 1



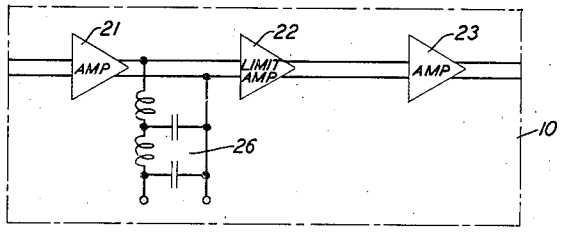


FIG. 2

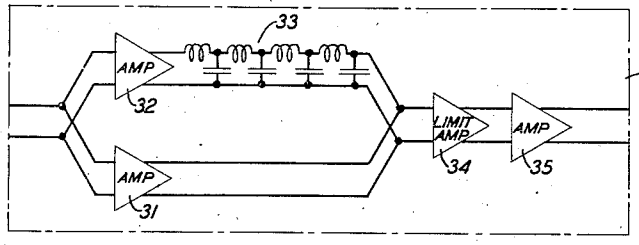


FIG. 3

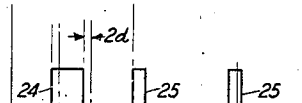


FIG. 4

FIG. 5

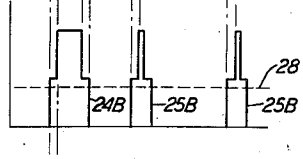


FIG. 6

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REPEATER FOR PULSE COMMUNICATION SYSTEM

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Application February 15, 1945, Serial No. 577,954

1 Claim. (Cl. 179—171)

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This invention relates to repeaters and particularly to repeaters for pulsed-type communication systems and more particularly to multiplex systems of that type.

An object of the invention is the correction of pulse distortion.

In electrical communication systems in which transmission is carried out by means of modulated pulses the conditions of transmission and the effects of terminal equipment may be such as to materially distort the shape of the pulses. In particular, in ultra-high frequency pulsed radio systems in which the radio pulses are generated by supplying direct current energizing pulses to a radio frequency oscillator, because of the shape of the leading edge of the direct current pulse or the time required for the radio oscillator to start, the resulting radio frequency pulses will be markedly shorter than the modulating pulses. In a usual type of radio repeater the received signals are brought down to the pulse frequency level where they are amplified and used to modulate a radio frequency transmitting oscillator in the same way as at the terminal. As a result the same pulse shortening effect is produced and the effect is cumulative. Where several repeaters are used in tandem the total effect may cause such a deterioration of the pulses as to seriously interfere with communication. Such effects are particularly noticeable in systems utilizing short pulses and operating at very high frequencies where direct amplification is difficult.

A particular object of the invention is to restore the length of pulses shortened by the effects of transiation or transmission.

In multiplex systems where adjacent pulses carry the modulations of different channels it is necessary that the system used for lengthening the pulses shall not produce such trailing edges on the reformed pulses as will extend over into the frame period assigned to an adjacent pulse. Such methods of pulse reshaping introduce cross-talk between channels which may be sufficiently great to be objectionable.

A further object of the invention is to lengthen the pulses of a multiplex system without introducing cross-talk between channels.

In accordance with a feature of this invention the repeater includes a delay network for producing a second pulse following each input pulse to the repeater by a time equal to the desired increase in length for the repeated pulses which should not be greater than length of the input pulse. The combination of each transmitted pulse and its corresponding delayed pulse when subjected to proper clipping and amplification results in a new pulse of increased length. The delay network may be included in one of two parallel paths, the other of which contains no delay. However, the preferable arrangement is to connect across the repeater one set of terminals of a delay network that is open-circuited at the other set of terminals. As a result, the effect of a pulse in the repeater is to produce a second pulse reflected from the open-circuited end of the delay network and consequently following the first pulse at a time equal to twice the delay time of the network.

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These and other objects, features and aspects of the invention may be better understood by reference to the following detailed description in connection with the drawing in which:

Fig. 1 is a block schematic showing of repeated pulsed radio telephone systems in accordance with the invention;

Fig. 2 is a detailed block schematic diagram of the repeater of Fig. 1;

Fig. 3 is a detailed block schematic of a modified form of the repeater 9, Fig. 1; and

Figs. 4, 5 and 6 are explanatory diagrams of the operation of the repeater.

Fig. 1 shows a one-way multiplex pulse modulation radio system comprising a transmitting terminal 1, a radio repeater 2 and a receiving terminal 3. As indicated by the spacing and dotted line between the radio repeater 2 and the receiving terminal 3, other radio repeaters may be included in the system as required by distance separating the terminals and the nature of the intervening country.

The transmitting terminal 1 comprises a multiplex transmitter 5 of any of the known types of time division pulse modulation, for example, a pulse position modulation system as shown in the copending application of J. O. Edson, Serial No. 559,354, filed October 19, 1944. The output of the multiplex transmitter is applied to the radio transmitter 6 which is keyed to produce pulses of ultra-high frequency radio oscillations by the pulse output of the multiplex transmitter. These radio waves are transmitted from a directional antenna 7.

The waves from the antenna 7 are received at the repeating station 2 in an antenna 8, detected in the radio receiver 9 and the resultant direct current pulses supplied to the repeater 10 where they are amplified and reshaped and supplied to a radio transmitter 11 similar to the transmitter 6. The resultant pulses of radio

waves from the transmitter 11 are radiated by the directional antenna 12.

At the receiving terminal 3 the waves from the antenna 12 or a similar antenna of a subsequent repeater are received in the antenna 13, detected in the radio receiver 14 and the resultant pulses supplied to the receiving multiplex 15 which may be of the type disclosed in the Edson application identified above.

Fig. 2 shows one form of the repeater 10. This comprises an amplifier 21 the output of which is coupled to the input of a limiting amplifier or clipper 22. Connected across the connections between the amplifiers 21 and 22 is one set of terminals of the delay network 26 which is desiged to match the impedance of the connecting circuit. The delay network 26 is open-circuited at its other terminal. It is necessary that the upper frequency at which the network 26 operates be sufficiently high that the edge of the reflected pulse does not trail off so as to extend into the period assigned to an adjacent pulse. The output of the limiting amplifier 22 is connected to the input of a final amplifier 23.

The operation of the repeater 10 can be best understood by reference to the diagrams of Figs. 4, 5 and 6 in each of which voltage is plotted against time to show the wave form of various components in the system.

Fig. 4 shows the output of the amplifier 21 comprising the marker or synchronizing pulse 24 and two of the channel pulses 25. In Fig. 5 the output of the delay network 26 is shown. This comprises the delayed marker pulse 24A and the delayed channel pulses 25A. All of these pulses are delayed with respect to the exciting pulses of Fig. 4 by a time $2d$ equal to twice the delay (d) of the network 26. The input to the clipper or limiting amplifier 22 is shown in Fig. 6. This comprises the sum of the pulses of Figs. 4 and 5 as may be seen by observation. The effect of the clipper 22 is to transmit only those amplitudes below the limiting value represented by the dotted line 28. This results in an output from the clipper 22 represented by the lower portion of the pulses 24B and 25B. These will be observed to be pulses of the same general type as the original pulses 24 and 25 but each lengthened by an amount $2d$. The increase of length of each pulse is the same and independent of the relative lengths of the original pulses. By proper design of the delay network, the increase may be made to substantially compensate the shortening that takes place in the transmitting oscillator.

These reformed or lengthened pulses 24A and 25B after being subjected to the clipping action of the amplifier 22 are amplified in the subsequent amplifier stages 23 to the amplitude required for keying the transmitter 11 in the same way that the terminal transmitter 6 is keyed.

Fig. 3 shows a modified form of the circuit of the repeater 10. In this circuit the output of the radio receiver 9 is branched to two amplifiers 31 and 32. The output of amplifier 31 is supplied directly to the input of the limiting amplifier 34. The output of the amplifier 32 is supplied through the delay network 33 to the amplifier 34. In this case, as in that of Fig. 2, the input to the amplifier 34 will be the sum of two sets of pulses one directly through the amplifier 31 and the other delayed by the network 33. In this case the amount of delay produced will be exactly equal to the delay time of the network 33 since the transmission therethrough is in only one direction. Accordingly, in order to obtain the same length correction the network 33 must have twice the delay of the network 26. The clipping action of the limiting amplifier 34 and the subsequent amplification by the amplifier 35 is the same as by the corresponding amplifiers 22 and 23 of Fig. 2.

What is claimed is:

In a system for communication by modulated pulses of high frequency waves at least one repeater including a receiver for detecting the incoming high frequency waves, an amplifier for the pulse output of said receiver, a transmitter for generating new pulses of high frequency waves in response to the pulse output of said amplifier and operating inherently to produce pulses of high frequency waves of shorter duration than the signal pulse input from said amplifier, and a pulse shaping circuit associated with said amplifier and comprising an open-ended delay network having its input terminals connected to the amplifier path and of such characteristics as to reflect each pulse at said terminals with a time delay less than the length of any pulse to be transmitted, and means for clipping the combined directly transmitted and reflected pulses to produce shaped pulses of substantially uniform amplitude and of length greater than the input pulses by an amount equal to the time delay of the reflected pulses.

GEORGE H. HUBER.

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