CIRCUIT FOR REMOVING NOISE

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This invention relates to improvements in receiver circuits adapted to receive pulses of energy, and particularly to an improved receiver circuit having means therein for removing the noise ripples from the received pulses.

It is known in the radio communication field to transmit messages in the form of constant amplitude and constant duration pulses of radio frequency energy which are modulated in number in the manner described in the copending application of Harold O. Peterson, Serial No. 517,484, filed January 8, 1944. The received pulses, however, very often contain undesirable noise ripples and variations in amplitude and duration.

The present invention has for its primary object to provide a circuit arrangement for removing from the received pulses the undesirable noise variations of both amplitude and duration.

A more detailed description of the invention follows in conjunction with a drawing, wherein Fig. 1 schematically illustrates one receiver embodiment of the invention for use in a pulsing system, and Fig. 2 graphically illustrates the operation of certain essential circuits in the receiver arrangement of the invention.

Fig. 1 shows one form of receiving arrangement which may be used in a pulse communication system for receiving pulses of radio frequency energy. The incoming pulses may be number modulated in suitable manner at the distant transmitter, not shown. In this type of modulation, often referred to as pulse number modulation, there are transmitted different numbers of pulses in accordance with the modulation.

One such system is described in the copending application Serial No. 517,484, filed January 8, 1944, by H. O. Peterson. Let it be assumed that the pulses emanating from the distant transmitter are of constant amplitude and constant duration. The receiver includes an antenna 40 which is indicative of any suitable energy collecting device, and which may be directive or otherwise. The antenna 40 feeds a radio frequency amplifier 41 whose output is connected to a heterodyne detector or frequency converter 42.

Converter 42 is also fed with energy from a local heterodyne oscillator 43 to produce energy of intermediate frequency which is amplified in selective intermediate frequency amplifier 44.

The intermediate frequency amplifier 44 has its output connected to a rectifier 45, in turn followed by a clipper amplifier 46. The clipper 46 removes a portion of the rectified pulse between the top and bottom to thereby provide a clean pulse having the noise ripples removed from the spaces between incoming pulses and from the desired flat tops of the incoming pulses. It is preferred, as will appear hereinafter, that the clipper be a top and bottom limiter which removes noise and variations above and below certain limits. The clipped pulses in the output of clipper 46 will, however, have variations of their length and phase caused by noise. The middles of these clipped pulses will be constant in amplitude.

The clipper 46 is followed by a pulse widener 47 which can be shunted out of the circuit by a switch S in the event the incoming pulses are sufficiently long so as not to require a widener. The pulse widener 47 is followed by an adjustable delay circuit 48, in turn followed by a gate or keyer 49 (sometimes referred to as a shutter) of the vacuum tube type for passing only the middle portion of the applied pulses to the exclusion of portions on both sides of this middle portion.

The output of the gate or keyer 49, represented by lead 50, contains pulses which are of constant duration and constant amplitude but shorter than those from the pulse widener 47, and these pulses in lead 50 can be applied to a suitable filter or selective circuit (not shown), in turn followed by an arrangement for reproducing the original modulation. For example, if pulse number modulation is employed, the circuits connected to lead 50 may include a filter, an audio amplifier, and an acoustic transducer, such as headphones or a loudspeaker.

In order to synchronize the gate or keyer 49, there are provided an adjustable delay circuit 54, a pulse generator 53, a pulse frequency oscillator 52, and an automatic pulse frequency control circuit 51. The pulse frequency oscillator 52 may, if desired, be a saw-tooth oscillator which operates at the pulse frequency. This saw-tooth oscillator is controlled by the automatic pulse frequency control circuit 51, in turn receiving the incoming pulses from the clipper 46. The synchronization apparatus may be of any well known form, such as that used in the television art.

The delay circuits 48 and 54 assure the fact that the incoming pulses passed on to the gate or keyer 49 arrive at the proper time for the gate to pass only a central portion of the clipped pulses. Due to the fact that the synchronization circuits have inherent delay, it is desired that the clipped pulse be delayed at 48 and this delay correlated with the delay in the operation of the synchronization apparatus such that only the middle portion of the clipped pulse is passed on.
by the gate 49 to lead 50. The delay circuits are adjustable, and with suitable design of the various circuit elements, one or both of these delay circuits can be eliminated. One form of delay circuit, mentioned by way of example only, is an artificial line.

The pulse widener 41 can be any known suitable circuit, such as an unsymmetrical trigger of the self-restoring type involving two vacuum tube electrodes, such electrodes whose grid and anode electrodes are interconnected regeneratively. The time constants of such a trigger is such that it produces an output pulse whose duration is longer than the applied triggering or input pulse. Reference is made to the copending application of Miller and Shenk, Serial No. 492,973, filed June 30, 1943, for one form of trigger circuit which can be used as a pulse widener.

The clipper may be any type known in the art, and preferably comprise a pair of vacuum tubes in cascade, each biased by means of a high resistance grid coupling resistor. The first of these tubes has its grid supplied with a pulse of positive polarity from the rectifier 45 and passes only a certain positive portion of the applied rectified pulse. This positive portion saturates the tube so that the output therefrom is of substantially constant current for the duration of the pulse. Since the output voltage from this first tube is in the negative direction, it is necessary to invert the polarity thereof by means of a transformer whose output supplies a positive pulse to the grid of the second tube of the pair. This second tube removes any amplitude variations not removed by the first tube. It is thus possible to clip the incoming pulse between two levels and remove a desired portion of the incoming pulse.

In the operation of the receiver arrangement of the invention, it is assumed that the incoming pulses are relatively long and have the appearance shown in line A of Fig. 2, after rectification by rectifier 45. In this case, a pulse widener is not required to practice the invention and for this reason pulse widener 41 is shunted out by means of switch S, or the pulse widener may be eliminated altogether. It will be noted that the pulses of line A have numerous ripples which are representative of noise and other variations. These rectified pulses, after being clipped by the clipper 48, will have the appearance of the pulses shown in line B. The pulses of line B, if it should be noted, have the ripples removed and are representative of a desired portion or slice of the pulses of line A appearing between the two horizontal lines designated clipper levels. The pulses of line B are of constant amplitude but are variable in width or length, due to the effect of noise. The gate or keyer 49 eliminates the variations in width of the pulses of line B by permitting the passage of only a central portion of each of the clipped pulses, thus providing output pulses from the gate which are of constant width and constant amplitude. Line C of Fig. 2 indicates the shape of the pulses after passing through gate or keyer 49.

The gate 49 functions at the pulse frequency, so that if an incoming pulse is received, a fixed central portion thereof passes through the gate, while those portions on both sides of this central portion extending to the front and rear edges of the incoming pulses are prevented from passing through the gate. The clipped incoming pulses control the exact time of initiation of the cycle produced by the oscillator 52 through the synchronizing circuit 51. Since the gate 49 is made to work or open up at delayed fixed time intervals corresponding to the pulse rate, the shortened pulses which are finally passed through the gate always have the same phase relation as the pulses which are produced by the transmitter. In the case of pulse number modulation, if no pulse has been received, then although the gate 49 is open at the proper time to permit the passage of the central portion of a pulse, it will pass through the gate because of the fact that the noise ripples have been removed ahead of the gate.

In the event that the received incoming pulses are extremely short in length and it is difficult to obtain a central portion therefrom, it is then necessary to employ the pulse widener 41 to increase the width of the incoming pulse. In such a case, the switch S will be opened. For example, if pulses of the order of one-half microsecond are being received, (it is impractical at the present state of the art to produce shorter pulses than these) it would be impossible to remove a central portion of these extremely short received pulses which is free from variation at the edges due to noise. The use of a pulse widener is then necessary.

What is claimed is:

1. A pulse communication system wherein a series of recurring spaced pulses are transmitted, a receiver for receiving said pulses and for providing correspondingly positioned unidirectional current pulses, and means for eliminating extraneous and undesired current variations of an interfering character from said unidirectional pulses, said means comprising a top and bottom clipper for removing said variations from the spaces between pulses and from the tops of the pulses, a gate coupled to the output of said clipper, and means for operating said gate in synchronism with the unidirectional pulses and at such times that only an intermediate portion of the clipped pulses applied to said gate by said clipper is passed by said gate, to thereby produce pulses of constant width and constant amplitude, said intermediate portion constituting an area located between the front and rear edges of the clipped pulses.

2. A pulse communication system wherein a series of recurring spaced pulses are transmitted, a receiver for receiving said pulses and for providing correspondingly positioned unidirectional current pulses, and means for eliminating extraneous and undesired current variations of an interfering character from said unidirectional pulses, said means comprising a top and bottom clipper for removing said variations from the spaces between pulses and from the substantially flat top of the pulses, a gate coupled to the output of said clipper, an adjustable delay circuit located between the output of said clipper and the input of said gate, and means for operating said delay circuit in synchronism with the unidirectional pulses and at such times that only an intermediate portion of the clipped pulses applied to said gate by said clipper is passed by said gate, to thereby produce pulses of constant width and constant amplitude, said intermediate portion constituting an area located between the front and rear edges of the clipped pulses, the delay circuit being correlated with the delay in the operation of said synchronizing means such that only the central portion of the pulse applied to said gate is passed on by said gate.

3. A pulse communication system wherein a series of recurring spaced pulses are transmitted, a receiver for receiving said pulses and for pro-
viding correspondingly positioned unidirectional current pulses, and means for eliminating extraneous and undesired current variations of an interfering character from said unidirectional pulses, said means comprising a top and bottom clipper for removing said variations from the spaces between pulses and from the substantially flat tops of the pulses, a pulse widener coupled to the output of said clipper, a gate coupled to the output of said pulse widener, and means for operating said gate in synchronism with the unidirectional pulses and at such times that only an intermediate portion of the clipped and widened pulses applied to said gate is passed by said gate, to thereby produce pulses of constant width and constant amplitude, said intermediate portion constituting an area located between the front and rear edges of the clipped pulses.

4. A pulse communication system wherein a series of recurring spaced pulses are transmitted, a receiver for receiving said pulses and for providing correspondingly positioned unidirectional current pulses, and means for eliminating extraneous and undesired current variations of an interfering character from said unidirectional pulses, said means comprising a top and bottom clipper for removing said variations from the spaces between pulses and from the substantially flat tops of the pulses, a gate coupled to the output of said clipper, and means for operating said gate in synchronism with the unidirectional pulses, and at such times that only an intermediate portion of the clipped pulses applied to said gate by said clipper is passed by said gate, to thereby produce pulses of constant width and constant amplitude, said intermediate portion constituting an area located between the front and rear edges of the clipped pulses.

5. A pulse communication system wherein a series of recurring spaced pulses are transmitted, a receiver for receiving said pulses and for providing correspondingly positioned unidirectional current pulses, and means for eliminating extraneous and undesired current variations of an interfering character from said unidirectional pulses, said means comprising a top and bottom clipper for removing the noise from the spaces between pulses and from the tops of the pulses, a gate coupled to the output of said clipper, an adjustable pulse delay circuit located between the output of said clipper and the input of said gate, and means for operating said gate in synchronism with the unidirectional pulses and at such times that only an intermediate portion of the clipped pulses applied to said gate is passed by said gate, to thereby produce pulses of constant width and constant amplitude, and means including an adjustable delay circuit, a pulse frequency oscillator and a pulse generator under control of said oscillator, all coupled in a circuit extending from the output of said clipper to said gate.

6. A receiver arrangement for a pulse communication system for receiving recurring pulses of alternating current energy, comprising a rectifier for rectifying the alternating current pulses, a clipper coupled to the output of said rectifier for removing noise ripples from the tops of the rectified pulses and from the spaces between rectified pulses, an electron discharge device gate or keyer coupled to the output of said clipper, and means for operating said gate in synchronism with the received recurring pulses and at such times that only the central portion of the clipped pulses is passed by said gate, to thereby produce pulses of constant width and constant amplitude.

7. A receiver for a pulse communication system, comprising a frequency converter for converting the carrier wave of the incoming pulses to a lower frequency wave, a rectifier for rectifying the clipped pulses of said lower frequency wave, a top and bottom clipper for eliminating noise ripples from the rectified pulses and also noise in the intervals between pulses, a gate, and means for operating said gate in synchronism with the incoming pulses and at such times that only the central portion of the clipped pulses is passed by said gate, to thereby produce pulses of constant width and constant amplitude, said central portion constituting an area located between the front and rear edges of said clipped pulses.

8. In a pulse modulation system wherein alternating current pulses of constant amplitude and constant duration are transmitted, a receiver arrangement including a rectifier for rectifying the received pulses, a clipper stage for removing noise ripples from the top of and the spaces between rectified pulses, a gate following said clipper, and means for rendering said gate operative in synchronism with the received pulses and at such times to pass only a portion of the rectified and clipped pulses, said portion being located between the front and rear edges of the clipped pulses.

9. A pulse communication system wherein a series of recurring spaced pulses are transmitted, a receiver for receiving said pulses and for providing correspondingly positioned unidirectional current pulses, and means for eliminating extraneous and undesired current variations of an interfering character from said unidirectional pulses, said means comprising a clipper stage for removing the noise and variations from said pulses, a gate coupled to the output of said clipper stage, and means for operating said gate in synchronism with the source of unidirectional pulses and at such times that only an intermediate portion of the clipped pulses applied to said gate by said clipper is passed by said gate, to thereby produce pulses of constant width and constant amplitude, said intermediate portion constituting an area located between the front and rear edges of the clipped pulses.

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