

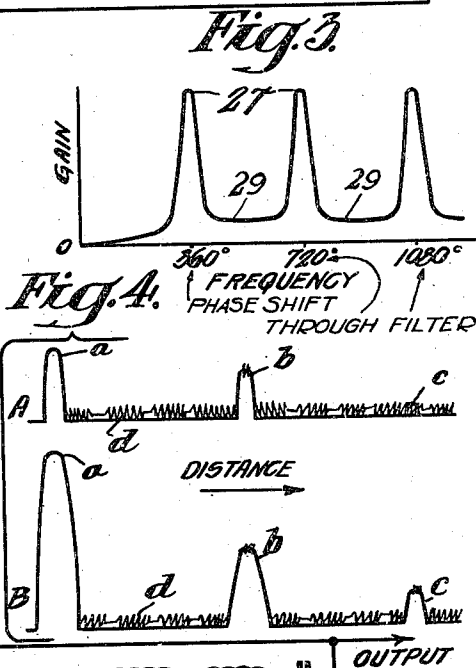
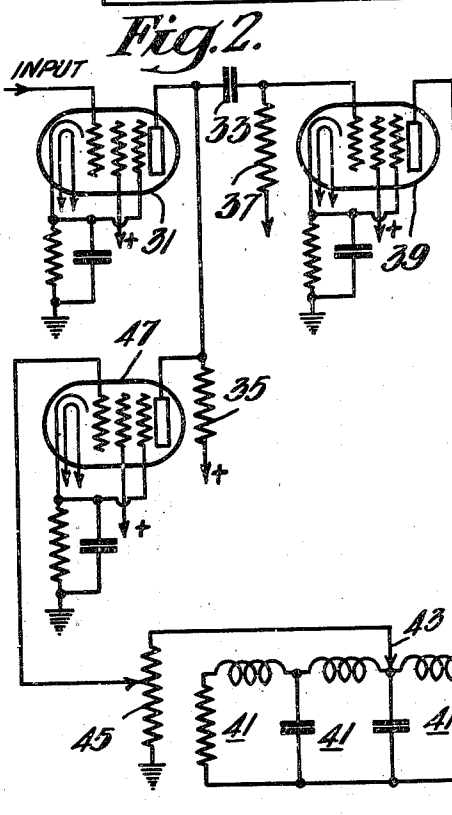
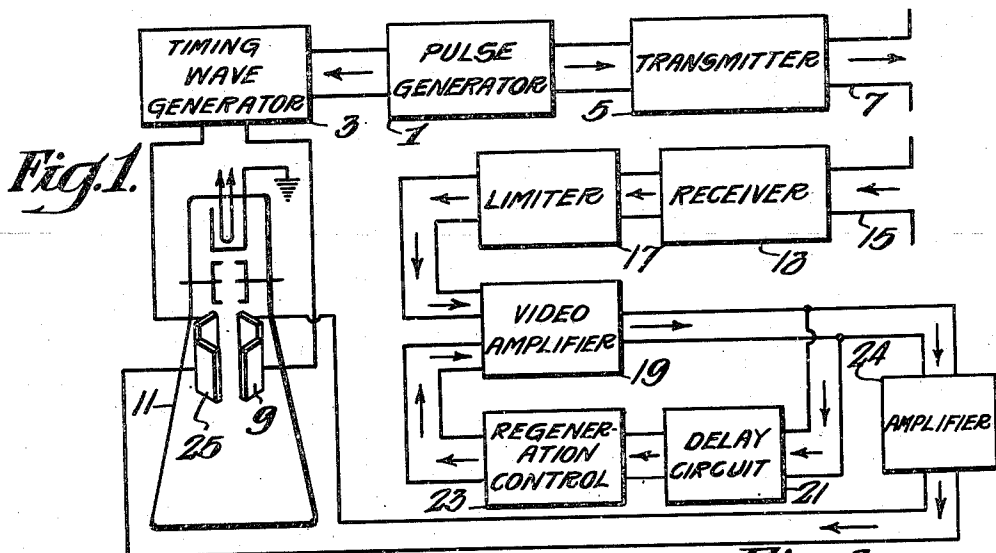
Nov. 15, 1949

S. M. TUCKER

2,487,995

PULSE-ECHO RECEIVER WITH REGENERATIVE FEEDBACK

Filed May 26, 1941



Inventor
Samuel M. Tucker
G. J. Huff
 Attorney

UNITED STATES PATENT OFFICE

2,487,995

PULSE ECHO RECEIVER WITH
REGENERATIVE FEEDBACK

Samuel M. Tucker, Jackson, Miss.

Application May 26, 1941, Serial No. 395,321

5 Claims. (Cl. 250-20)

1

This invention relates to pulse echo receivers and particularly to a pulse echo receiver in which the echo signals may be distinguished from background noise and electrical disturbances.

Obstacles may be detected by radiating pulses of radio frequency energy. The pulses, after reflection from an obstacle, may be received to indicate the presence of a wave reflecting object. The distance of a wave reflecting object may be indicated by timing the interval between the outgoing and incoming pulses. The timing may be indicated by using a cathode ray tube in which the sweep is started, along one coordinate, in synchronism with the outgoing pulse and in which the echo signals deflect the sweep along another coordinate or modulate the electron beam to indicate the received echoes.

If the radio receiver is broadly tuned to include all components of the pulse frequencies, it will exhibit a signal to noise ratio which becomes less favorable with increasing band width. The term "noise" is used to describe electrical disturbances originating within or without the receiver. When the reflecting object is located at a considerable distance, the reflected energy will be small and the ratio of signal to noise will be unusually low. Furthermore, fading may take place so that the signal will be very weak. Thus, the maximum range of a conventional pulse echo system is limited by the ratio of signals to noise.

One of the objects of the present invention is to provide improved means for receiving pulse echo signals. Another object is to provide improved means for distinguishing pulse echo signals from electrical disturbances. Another object is to provide means for amplifying selectively regularly recurrent pulses of signal energy. A further object is to provide in a pulse echo receiver means for amplifying regeneratively the regularly recurrent pulses of signal energy.

The invention will be described by referring to the accompanying drawings in which Figure 1 is a schematic block diagram of one embodiment of the invention; Figure 2 is a circuit diagram of an amplifier and delay network employed in the arrangement of Fig. 1; and Figures 3 and 4 are graphs used in illustrating the operation of the invention.

Referring to Fig. 1, a pulse generator 1 is connected to a timing wave generator 3 and to a transmitter 5. The transmitter is connected to an antenna 7, which is preferably directive. The timing wave generator is connected to one pair of deflecting elements 9 of a cathode ray tube 11. A receiver 13, which may be connected to the trans-

2

mitter antenna 7 or a separate antenna 15, is connected through a limiter 17 to a video amplifier 19. The output of the video amplifier is connected, through a delay circuit 21 and a regeneration control 23, to its input circuit. The output of the video amplifier is also connected, preferably through an amplifier 24, to the second set of deflecting electrodes 25 of the cathode ray tube.

The operation is essentially as follows: The pulse generator establishes sharply defined pulses at a rate fixed by the maximum distance range. For example, for ranging at distances of the order of 93 miles, the pulse rate would be about 1000 per second. If the distances are to be measured very accurately, the pulse length should be short. The generated pulses are simultaneously applied, through the transmitter, to the antenna and to the timing wave generator. The voltages from the timing wave generator are chosen to sweep the cathode ray across the cathode ray tube screen in synchronism with the outgoing pulses and as a function of the distance to be measured.

The echo signals are amplified and detected in the receiver 13 and may be passed through a limiter 17 whose function is to limit the amplitude of the electrical disturbances of large amplitude, including the strong outgoing pulses. The detected signals, as well as electrical disturbances of lesser amplitude, are passed through the video amplifier 19. The amplified signals are passed through a delay circuit in which they are delayed so that the thus delayed signals are applied to the input of the video amplifier in phase with the incoming signals applied directly to the input. The amount of feedback is regulated by the regeneration control 23, which may precede or follow the delay circuit. The feedback is maintained below the value at which self-oscillation would occur.

Furthermore, the delay circuit is preferably adjusted so that the unamplified and amplified feedback pulses will be of exactly the same phase at the input of the amplifier. The effect of the feedback is shown in Fig. 3 in which the peaks 27 are greatly amplified with respect to the amplifier gain at all other frequencies represented by the line 29 parallel to the base of the graph. The electrical disturbances or noises originating within or without the amplifier or system and of frequencies different from the pulse frequency pass through the amplifier and delay network in such phase as will not cause regeneration. Thus, the desired signals are distinguished from the disturbances as shown in Fig. 4 in which the graph A represents a conventional pulse echo system and

the graph B represents the improved system of the instant invention, both being indicated on the fluorescent screen of a cathode ray tube. In the graphs, *a* represents an initial pulse, *b* a strong pulse, *c* a weak pulse, and *d* noise.

One suitable circuit for obtaining selective amplification is shown in Fig. 2 in which the first thermionic tube 31 of the video amplifier is connected through a capacitor 33 and resistors 35, 37 to the second amplifier 39. The output of the second amplifier is connected to the input of the delay circuit, which in the present arrangement includes a plurality of sections of a filter. The number of sections 41 are so chosen that the delay is equal to the interval between pulses. The exact delay is determined by adjusting the tap 43 which is connected at the required point along the line. The amount of feedback is selected by a potentiometer 45 from which the feedback signal is applied through an isolating tube 47 to the input of the second amplifier. While the feedback signal may be applied directly to the input of the first tube 31 by any suitable isolating network, the use of an isolating tube is a preferred means of keeping the signals from bypassing the amplifier by way of the delay circuit.

In the course of experiments, it has been found that the delay circuit tends to broaden the pulses but the slight broadening is more than offset by the gain in amplitude. As shown in Fig. 4A, the weak signal *c* is practically indiscernible in a conventional receiver, and is readily discernible in the improved receiver. It should be understood that the selective amplifier is not limited to any particular circuit nor to any special type of delay circuit. For example, the delay may be obtained by an electrical circuit or by some means such as sound waves in a rod of metal or other column of the length required to produce the desired delay. Furthermore, regeneration may be applied at video, intermediate, or radio frequencies. The phasing of the pulses at video frequencies is not as difficult as at intermediate or radio frequencies and is therefore preferable.

The invention described herein may be manufactured and used by or for the Government of the United States for governmental purposes only without the payment of any royalty thereon.

I claim as my invention:

1. A pulse echo receiver including in combination means for detecting regularly recurrent signals and continuously detecting undesired random noises, a video amplifier connected to said detecting means for amplifying said detected signals and noises, and a delay circuit effectively connected between the input and output of said amplifier for regeneratively applying to the input of said amplifier said amplified recurrent signals only so that said regularly recurrent signals are selectively and regeneratively amplified with respect to said random noises.

2. A pulse echo receiver including in combination means for detecting regularly recurrent signals and continuously detecting undesired random noises, a video amplifier connected to said detecting means for amplifying said detected signals and noises, a delay circuit effectively connected between the input and output of said amplifier for regeneratively applying to the input of said amplifier amplified recurrent signals only so that said regularly recurrent signals are selec-

tively and regeneratively amplified with respect to the random noises, and means for indicating visually the increased amplitude of the regularly recurrent signals by reference to the unaltered amplitude of said noises occurring between recurrent signals.

3. A pulse echo receiver including in combination means for detecting regularly recurrent signals, an amplifier connected to said detecting means for amplifying said detected signals, a delay circuit effectively connected between the input and output of said amplifier for applying amplified signals in phase with the signals applied initially to the input of said amplifier so that said regularly recurrent signals are selectively and regeneratively amplified, and means for preventing the signals applied to the input of said amplifier from by-passing said amplifier through said delay circuit.

4. The method of distinguishing objects by means of reflected pulse echoes from undesired random background noises which includes radiating pulses of energy at a predetermined rate, receiving said pulses after reflection and also receiving said undesired background noises, said received pulses recurring at said predetermined rate, amplifying said recurrent received pulses and said undesired noises, feeding back regeneratively said recurrent received pulses only thereby to amplify further said recurrent received pulses only without further amplifying said undesired random noises whereby the objects represented by said echoes may be more clearly distinguished from the undesired background noises.

5. The method of receiving regularly recurrent pulse echo signals which includes receiving said echo signals and undesirable random background noises, detecting said received signals and said noises, amplifying said detected signals and said noises, delaying said amplified signals and noises by an amount substantially equal to the interval between recurrent signals, feeding back said delayed signals and noises to obtain regenerative amplification of the recurrent signals only whereby said recurrent echo signals are of increased amplitude with respect to the background noises, and indicating the regeneratively amplified signals visually.

SAMUEL M. TUCKER.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,203,634	Richards	June 4, 1940
2,212,173	Wheeler et al.	Aug. 20, 1940
2,221,666	Wilson	Nov. 12, 1940
2,225,524	Percival	Dec. 17, 1940
2,227,057	Blumlein	Dec. 31, 1940
2,227,598	Lyman et al.	Jan. 7, 1941
2,236,015	Sonntag	Mar. 25, 1941
2,255,839	Wilson	Sept. 16, 1941
2,310,692	Hansell	Feb. 9, 1943
2,361,437	Trevor	Oct. 31, 1944

FOREIGN PATENTS

Number	Country	Date
480,572	Great Britain	Feb. 24, 1938