May 27, 1947. H. A. WHEELER 2,421,138

WAVE SIGNAL TRANSLATING ARRANGEMENT

Filed June 1, 1945

FIG. I

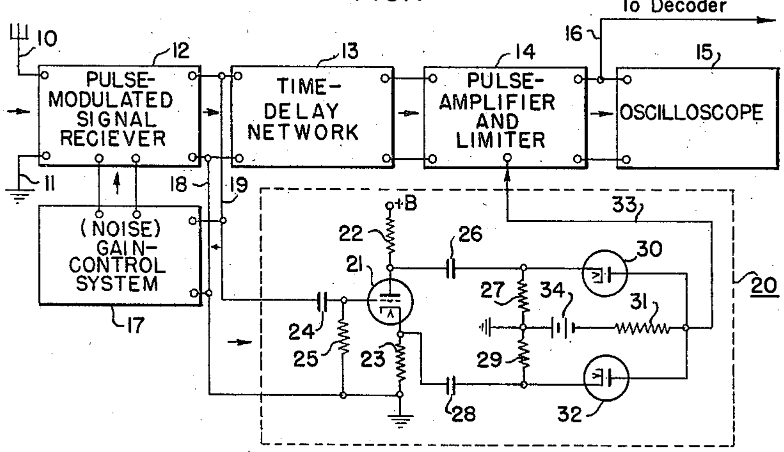
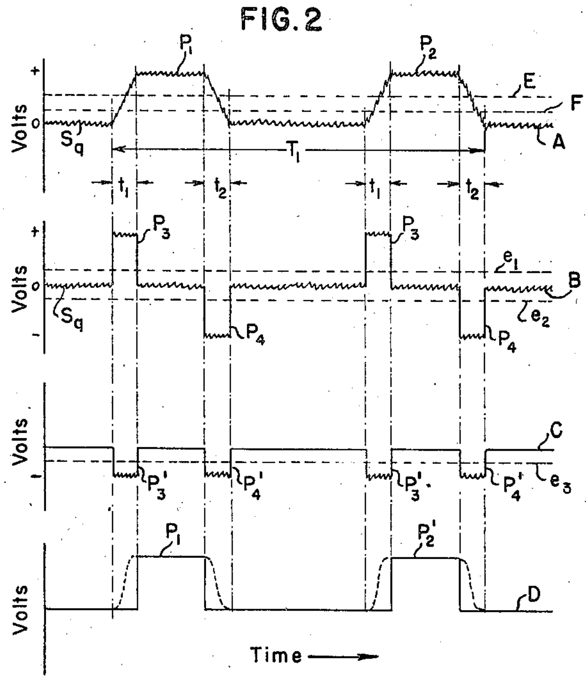


FIG. 2



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WAVE SIGNAL TRANSLATING ARRANGEMENT

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9 Claims. (Cl. 178—44)

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This invention is directed to wave-signal translating arrangements for translating pulse signals which may have one or more sloping edges. Although the invention is subject to a variety of applications, it is especially suited for use in a radio-locating and direction-finding system of the type utilizing pulse-modulated signals and it will be particularly described in that connection.

In one radio-locating and direction-finding system of the type under consideration, the desired information is conveyed by means of a pulse signal, coded in accordance with a prescribed coding schedule. For example, the coded signal may include a pair of pulse components, individually having a fixed duration and a time separation that is variable in a code sequence. In the preferred system, the coded signal is received, shaped and passed on to a decoder unit which automatically derives the desired information by deciphering the received signal.

The coded signal is shaped, in the usual case, by means of a conventional limiter in which the received pulses are clipped off at a predetermined amplitude level. Such an arrangement performs the desired wave-shaping function but is subject to an operating limitation which may be undesirable in certain installations. This limitation follows from the fact that variations in signal strength of the received signal cause variations in the slope of leading and trailing edges of the pulse components. As a consequence, the ordinary limiter which operates at a fixed amplitude level produces in its output circuit pulse signals having pulse widths that also vary in accordance with the received signal strength. This becomes objectionable where the pulse widths of the code components of the received signal are significant.

Circuit arrangements for responding to the sloping edges of applied pulse signals have already been proposed. In one prior arrangement a control potential is derived, having a magnitude that varies with the slope of one edge of the applied signal. The potential is developed across a conventional time-constant circuit and is used to control the gain of a receiver to maintain the amplitude of the signal delivered therefrom within a relatively narrow range for a wide range of received signal intensities. Such control arrangements, while providing a suitable automatic-gain-control potential, are not effective to shape the edges of the translated pulse signal as is required to avoid the aforementioned pulse-width variations inherent in conventional limiting of pulse signals which have sloping edges.

It is an object of the present invention, therefore, to provide an improved wave-signal translating arrangement for translating pulse signals which substantially avoids one or more of the aforementioned limitations of prior arrangements.

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It is another object of the invention to provide an improved wave-signal translating arrangement for translating a pulse signal which may have a sloping edge and for effectively suppressing the sloping edge.

It is a particular object of the invention to provide an improved wave-signal translating arrangement for translating a pulse signal which may have sloping, leading and trailing edges and for deriving therefrom a pulse signal having substantially vertical edges.

In accordance with the invention, a wave-signal translating arrangement for translating a pulse signal which may have a sloping edge comprises a controllable signal-translating channel for supplying the signal to a utilizing device. The arrangement has means connected to the channel at one point and responsive to the sloping edge of the pulse signal for deriving a control potential. Also, means are provided for applying the control potential to a succeeding point in the channel to interrupt signal translation at the succeeding point for an interval having a duration approximately equal to, and a substantial time coincidence with, the occurrence of the sloping edge of the pulse signal at the succeeding point, effectively to suppress the sloping edge in the signal translated through the channel.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

In the drawing, Fig. 1 represents a wave-signal translating arrangement including the present invention in a preferred form, and Fig. 2 comprises graphs utilized in explaining the operation of the Fig. 1 arrangement.

Referring now more particularly to Fig. 1, the wave-signal translating arrangement there represented may be considered as the receiving unit of a radio-locating and direction-finding system. The arrangement comprises an antenna-ground system 10, 11 for intercepting pulse-modulated direction-finding signals which may have sloping, leading and trailing edges. The antenna system 10, 11 is coupled to the input terminals of a controllable signal-translating channel through which received pulse-modulated signals are supplied to a utilizing device. This channel is provided by a pulse-modulated wave-signal receiver 12, a time-delay network 13, a pulse amplifier and limiter 14, and an oscilloscope 15 connected in cascade in the recited order. The receiver unit 12 may constitute any conventional well-known arrangement for receiving and demodulating pulse-modulated signals, such as a receiver of the superheterodyne type. The pulse amplifier and limiter 14 may comprise an amplifying arrangement of any desired number of stages in at least one of which applied pulse signals are shaped by clipping and amplitude-limiting actions. This may be accomplished by adjusting the operating potentials of the stage so as to translate only an intermediate amplitude range of an applied pulse signal, eliminating the maximum and minimum levels thereof by way of the well-known anode-current saturation and anode-current cutoff phenomena, respectively. The time-delay network 13 and oscilloscope 15 may be of conventional constructions, the oscilloscope preferably being of the cathode-ray type used to monitor the wave-signal translating arrangement under consideration. The pulse-modulated signal obtained in the output circuit of limiter 14 may be applied to an automatic decoding unit (not shown), as indicated by arrow 16.

A gain-control system 17 is coupled by way of conductors 18 and 19 to the output circuit of receiver 12 for controlling the gain of channel 12–15, inclusive. Preferably, the gain-control system is of the type which utilizes the quiescent or noise signal output of receiver 12 to stabilize the receiver gain at a desired normal value. If desired, there may also be associated with receiver 12 a pulse gain-control system of the type particularly described in copending application Serial No. 597,035, filed concurrently herewith in the name of Harold A. Wheeler and assigned to the same assignee as the present invention. Such a pulse gain-control system is insensitive to the quiescent signal output of receiver 12, that is to say, it is ineffective in the absence of a received pulse-modulated signal. Upon receipt of such a signal, however, the pulse gain-control system responds rapidly to develop a control potential for materially reducing the gain of channel 12–15, inclusive, early in the duration of the received signal. The condition of reduced gain endures for an interval slightly greater than the duration of the received pulse-modulated signal and is effective to suppress the effects of spurious or interfering signals which may be received along with a coded pulse-modulated signal, as particularly described in the copending application. An output circuit of the noise gain-control system 17 is coupled to a control input circuit of receiver 12 for applying control potentials to the receiver for the purpose of controlling its gain.

The signal-translating arrangement has means, designated 20, connected to the signal-translating channel at one point and responsive to the sloping edge of a received pulse-modulated signal for deriving a control potential. For the illustrated embodiment where it is desired to effect a shaping or correction of both the leading and trailing edges of received pulse signals, this means comprises a differentiating circuit for deriving a first pair of pulses having opposite polarities. More specifically, unit 20 includes an amplifier comprising a triode vacuum tube 21 having an anode impedance 22 and an equal cathode impedance 23 arranged to provide a balanced output circuit for the amplifier. A coupling condenser 24 and leak resistor 25 in conjunction with conductors 18 and 19 connect the input circuit of tube 21 to one point, specifically the output circuit of receiver 12, of channel 12–15, inclusive. A condenser 26 and resistor 27 coupled to the anode impedance 22 of amplifier 21 constitute a first differentiating circuit while a condenser 28 and resistor 29 similarly connected to the cathode impedance 23 constitute a second differentiating circuit. Each such circuit is selected to have a time constant which is very much less than the slope time, that is, the duration of the slope portions of the pulse signals applied to unit 20 from receiver 12.

A full-wave rectifier system is associated with the differentiating circuits for developing, from a first pair of pulses derived in the differentiating circuit, a second and corresponding pair of pulses which individually are of the same polarity. The rectifying system comprises a first diode 30 coupled between resistor 27 and a common load impedance 31 and a second diode 32 coupled between resistor 29 and common load impedance 31. A battery 34 or other potential source applies an amplitude-delay bias to each diode 30 and 32, rendering the rectifier system unresponsive to the quiescent signal translated in channel 12–15, inclusive, in the absence of a received pulse-modulated signal. A connection 33 extending from the common load impedance 31 to a control input terminal of unit 14 constitutes means for applying the pulses of control potential derived in unit 20 to such a succeeding point in the channel as to interrupt signal translation thereat for an interval approximately equal to, and occurring in time coincidence with, the occurrence of the edges of the pulse signal at this succeeding point to suppress the edges of the signal translated in channel 12–15, inclusive.

While a transmitting unit is customarily associated with the arrangement represented in Fig. 1 to complete the radio-locating and direction-finding system, the present invention may be clearly understood from a consideration of the receiver portion only. For this reason the remainder of the direction-finding system has been omitted from the drawing. The operation of the Fig. 1 arrangement is represented in part by the curves of Fig. 2.

Curve A represents the signal output obtained from receiver 12 of the signal-translating channel 12–15, inclusive. The low-amplitude signal portions designated S_q denote the quiescent signal output of the receiver obtained in the absence of a received signal. This quiescent signal is initiated by and represents inherent disturbances within the receiver as, for example, thermal agitation noise, shot effect and the like. Gain-control system 17 utilizes the quiescent signal output to stabilize the receiver gain and maintain the amplitude of its quiescent signal at or below a preselected amplitude level. The pulse components P_1 and P_2 constitute a received direction-finding signal of the pulse-modulated type which has a duration T_1. The time separation of these pulse components is coded in accordance with a prescribed coding schedule. Each of the pulse components P_1 and P_2 has sloping, leading and trailing edges and an intermediate flat or plateau portion.

The signal of curve A is applied to unit 20, amplified in tube 21, and differentiated in the differentiating circuits associated with the balanced output arrangement of tube 21. The differentiated signal thus established across resistor

29 has the wave form and polarity of curve B. It contains a pair of pulses of opposite polarity for each of the code components P_1 and P_2. The positive-polarity pulse P_3 of each pair is derived from the leading edge of one of the code components and has a duration t_1 equal to that of the leading edge of the code component. The negative-polarity pulse P_4 of each pair is derived from and has a duration t_2 equal to that of the trailing edge of each of the code components P_1 and P_2. The differentiated signal established across resistor 27 has an identical wave form but reversed polarity, a polarity reversal being obtained in translation of the signal of curve A through tube 21 to its anode circuit.

Each of diodes 30 and 32 rectifies the pulses of negative polarity applied to its cathode from resistor 27 or 29, developing across the common load impedance 31 the signal of curve C. This signal also has a pair of pulse components representing the sloping edges of each of the code components P_1 and P_2 and of negative polarity. The first pulse P_3' of each such pair corresponds with the leading edge of one code component and is obtained by way of diode 30. The alternate pulse P_4' of each pair corresponds with the trailing edge of each code component and is derived through the alternate diode 32. The broken horizontal lines e_1 and e_2 designate the amplitude-delay bias applied to the diodes 30 and 32. The delay bias is such that signal components of curve B which lie between the bias levels, such as the quiescent signal components S_q, are not translated by the rectifier system and hence do not appear in curve C. The negative-polarity control pulses of curve C are applied as a pulse-modulated bias potential to a bias control circuit of pulse amplifier and limiter 14. Broken horizontal line e_3 represents the cutoff level of unit 14, demonstrating that each of the control pulses P_3' and P_4' is effective to bias the pulse amplifier and limiter to anode-current cutoff for intervals which correspond to the duration of the leading and trailing edges of code components P_1 and P_2.

In order to simplify the graphical representation, the curves of Fig. 2 neglect the time-delay of network 13 and, additionally, neglect the delay in deriving the control pulses of curve C. In practical circuit applications some time delay is generally encountered in the derivation of the desired control pulses. Accordingly, the delay of network 13 is adjusted to a corresponding value so that the control pulses P_3' and P_4' of curve C block unit 14 and interrupt signal translation thereat during spaced operating intervals which have a duration approximately equal to, and a substantial time coincidence with, the occurrence at unit 14 of the leading and trailing edges respectively of the code components P_1 and P_2. Therefore, the output signal of pulse amplifier and limiter 14 has the wave form of curve D. The code components P_1' and P_2' of curve D represent that portion of each of code components P_1 and P_2 of curve A that is translated by unit 14 in view of the control established thereon by the control potential of curve C. Specifically, the control potential of curve C, by blocking unit 14 during the intervals t_1 and t_2, suppresses or eliminates the sloping edges in the signal translated. Therefore, the code components P_1' and P_2' of curve D correspond with that fraction of the flat or plateau portion of each component P_1 and P_2 that occurs within the limiting levels of limiter 14, which levels are represented by horizontal lines E and F. The code components of curve D have a width that is independent of the limiting levels E and F since the sloping edges of the code components are not translated by unit 14.

The signal of curve D, in turn, is applied to the oscilloscope 15 where the performance of the channel 12–15, inclusive, may be determined by reproducing the wave form of curve D on the screen of a cathode-ray tube in well-known fashion. This output signal of the limiter 14 may also be supplied to the automatic decoder (not shown) wherein the coded information conveyed by means of the time separation of code components P_1 and P_2 is deciphered. Unit 20 which suppresses the sloping edges of the translated code components permits the limiting action of unit 14 to be accomplished without effecting the pulse width of the code components supplied to the decoder. This assures improved operation of the decoding mechanism.

The broken-line curve portions of curve D represent the signal output of a conventional limiter having the limiting levels shown by horizontal lines E and F but operating upon the sloping portions of the code components as well as the flat or plateau portions thereof. It is evident that in such an arrangement the width of the limited pulses varies in accordance with the slope of the leading and trailing edges of the code components as well as the limiting levels. This result is avoided by the inclusion of unit 20 in the signal-translating arrangement of Fig. 1.

In the illustrated embodiment of the invention the control pulses of curve C derived at one point in channel 12–15, inclusive, are applied to a succeeding point in the channel so as to suppress both the leading and trailing sloping edges from the signal translated. By omitting the function of either diode 30 or 32, the arrangement may be utilized to suppress only one of the sloping edges of the pulse components where this operation should be desired. Also, the time-delay network 13 need not necessarily take the form of a pure time-delay mechanism. Where a sufficient number of stages are included in unit 14, the time of translation therethrough may correspond with the delay of unit 20 in deriving the control pulses. In such a case connection 33 may be made directly with a particular stage of unit 14 wherein the sloping edges of the pulse signals occur in time coincidence with the control pulses obtained from the rectifier system of unit 20.

While there has been described what is at present considered to be the preferred embodiment of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A wave-signal translating arrangement for translating a pulse signal which may have a sloping edge comprising, a controllable signal-translating channel for supplying said signal to a utilizing device, means connected to said channel at one point and responsive to said sloping edge of said signal for deriving a control potential, and means for applying said control potential to a succeeding point in said channel to interrupt signal translation at said succeeding point for an interval having a duration approximately equal to and a substantial time coincidence with the occurrence of said sloping edge of said signal

at said succeeding point effectively to suppress said sloping edge in the signal translated through said channel.

2. A wave-signal translating arrangement for translating a pulse signal which may have a sloping edge comprising, a controllable signal-translating channel for supplying said signal to a utilizing device, means including a differentiating circuit connected to said channel at one point and responsive to said sloping edge of said signal for deriving a control potential, and means for applying said control potential to a succeeding point in said channel to interrupt signal translation at said succeeding point for an interval having a duration approximately equal to and a substantial time coincidence with the occurrence of said sloping edge of said signal at said succeeding point effectively to suppress said sloping edge in the signal translated through said channel.

3. A wave-signal translating arrangement for translating a pulse signal which may have a sloping edge comprising, a controllable signal-translating channel for supplying said signal to a utilizing device, means connected to said channel at one point and responsive to said sloping edge of said signal for deriving a control potential, time-delay means in said channel connected between said one point and a succeeding point for delaying said signal between said points by an interval corresponding to the time delay in deriving said control potential, and means for applying said control potential to said succeeding point to interrupt signal translation thereat for an interval having a duration approximately equal to and a substantial time coincidence with the occurrence of said sloping edge of said signal at said succeeding point effectively to suppress said sloping edge in the signal translated through said channel.

4. A wave-signal translating arrangement for translating a pulse signal which may have a sloping edge comprising, a controllable signal-translating channel for supplying said signal to a utilizing device, means connected to said channel at one point for differentiating said signal to derive a pulse of control potential having the same duration as said sloping edge, time-delay means in said channel connected between said one point and a succeeding point for delaying said signal between said points by an interval corresponding to the time delay in deriving said control potential, and means for applying said control potential to said succeeding point to interrupt signal translation thereat for an interval having a duration approximately equal to and a substantial time coincidence with the occurrence of said sloping edge of said signal at said succeeding point effectively to suppress said sloping edge in the signal translated through said channel.

5. A wave-signal translating arrangement for translating a pulse signal which may have a sloping edge comprising, a controllable signal-translating channel for supplying said signal to a utilizing device, means connected to said channel at one point for differentiating and rectifying said signal to derive a pulse of unidirectional potential having a predetermined polarity and having the same duration as said sloping edge, time-delay means in said channel connected between said one point and a succeeding point for delaying said signal between said points by an interval corresponding to the time delay in deriving said control potential, and means for applying said control potential to said succeeding point to interrupt signal translation thereat for an interval having a duration approximately equal to and a substantial time coincidence with the occurrence of said sloping edge of said signal at said succeeding point effectively to suppress said sloping edge in the signal translated through said channel.

6. A wave-signal translating arrangement for translating a pulse signal which may have sloping, leading and trailing edges comprising, a controllable signal-translating channel for supplying said signal to a utilizing device, means connected to said channel at one point and responsive to each of said sloping, leading and trailing edges for deriving therefrom a pair of spaced pulses of control potential having a duration equal to that of said leading and trailing edges respectively, time-delay means in said channel connected between said one point and a succeeding point for delaying said signal between said points by an interval corresponding to the time delay in deriving each of said pulses of control potential, and means for applying said pair of control pulses to said succeeding point to interrupt signal translation thereat during spaced intervals having a duration approximately equal to and a substantial time coincidence with the occurrence at said succeeding point of said leading and trailing edges respectively of said signal effectively to suppress said sloping edges in the signal translated through said channel.

7. A wave-signal translating arrangement for translating a pulse signal which may have sloping, leading and trailing edges comprising, a controllable signal-translating channel for supplying said signal to a utilizing device, means connected to said channel at one point for differentiating said signal to derive a first pair of pulses having opposite polarities and a duration equal to that of said leading and trailing edges respectively, full-wave rectifying means for developing from said first pair of pulses a second and corresponding pair of pulses of control potential individually having a given polarity, time-delay means in said channel connected between said one point and a succeeding point for delaying said signal between said points by an interval corresponding to the time delay in deriving each of said pulses of control potential, and means for applying said pair of control pulses to said succeeding point to interrupt signal translation thereat during spaced intervals having a duration approximately equal to and a substantial time coincidence with the occurrence at said succeeding point of said leading and trailing edges respectively of said signal effectively to suppress said sloping edges in the signal translated through said channel.

8. A wave-signal translating arrangement for translating a pulse signal which may have a sloping edge comprising, a controllable signal-translating channel for supplying said pulse signal to a utilizing device and effective in the absence of said pulse signal to translate a quiescent signal representing inherent disturbances within said translating arrangement, means connected to said channel at one point and unresponsive to said quiescent signal but responsive to said sloping edge of said pulse signal for deriving a control potential, and means for applying said control potential to a succeeding point in said channel to interrupt signal translation at said succeeding point for an interval having a duration approximately equal to and a substantial time coincidence with the occurrence of said sloping edge of said

signal at said succeeding point effectively to suppress said sloping edge in the signal translated through said channel.

9. A wave-signal translating arrangement for translating a pulse signal which may have a sloping edge comprising, a controllable signal-translating channel including a time-delay network and a succeeding pulse amplifier for supplying said signal to a utilizing device, means connected to said channel at a point preceding said time-delay network and responsive to said sloping edge of said signal for deriving a control potential, said time-delay network being effective to delay said pulse signal by an interval corresponding to the time delay in deriving said control potential, and means for utilizing said control potential to bias said pulse amplifier to cutoff for an interval having a duration approximately equal to and a substantial time coincidence with the occurrence of said sloping edge of said signal at said succeeding amplifier effectively to suppress said sloping edge in the signal translated through said channel.

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