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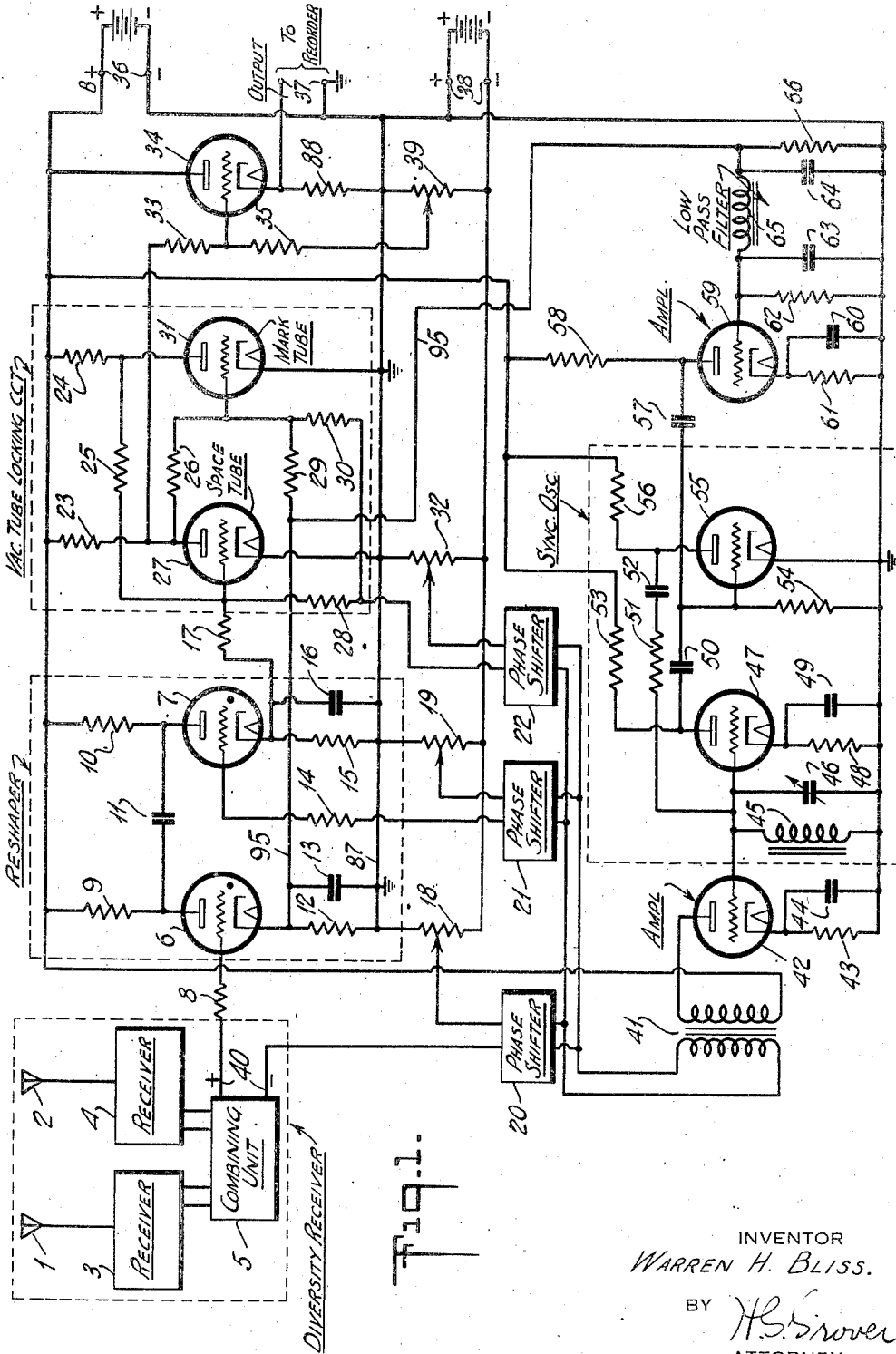
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2,457,974

PULSE TYPE TELEGRAPH RECEIVER

Filed June 17, 1943

5 Sheets-Sheet 1



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2,457,974

PULSE TYPE TELEGRAPH RECEIVER

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Fig. 2.

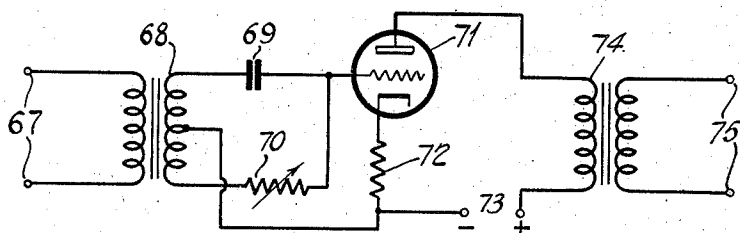
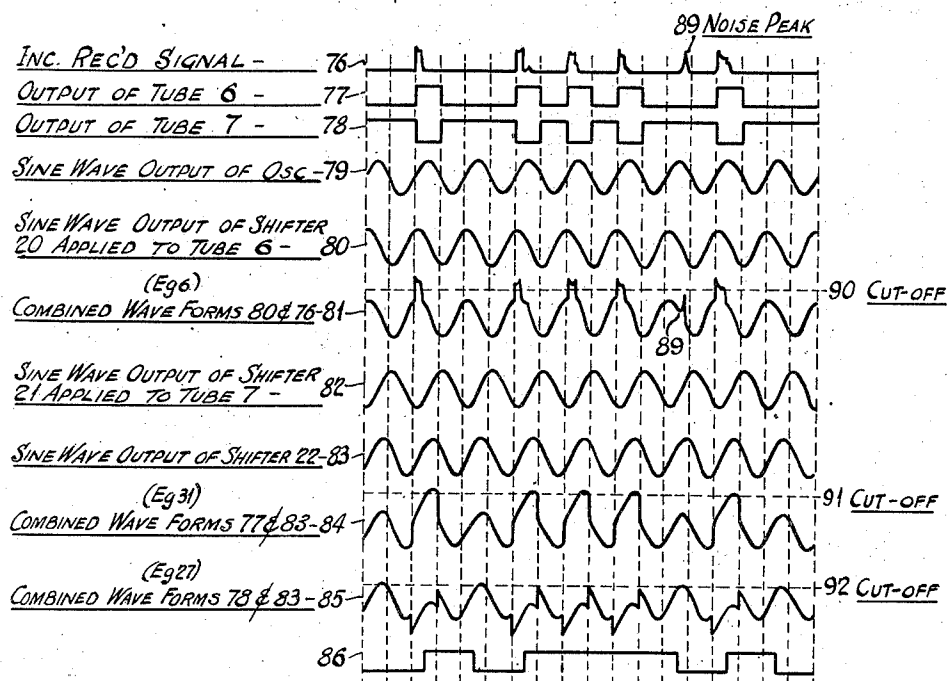


Fig. 3.



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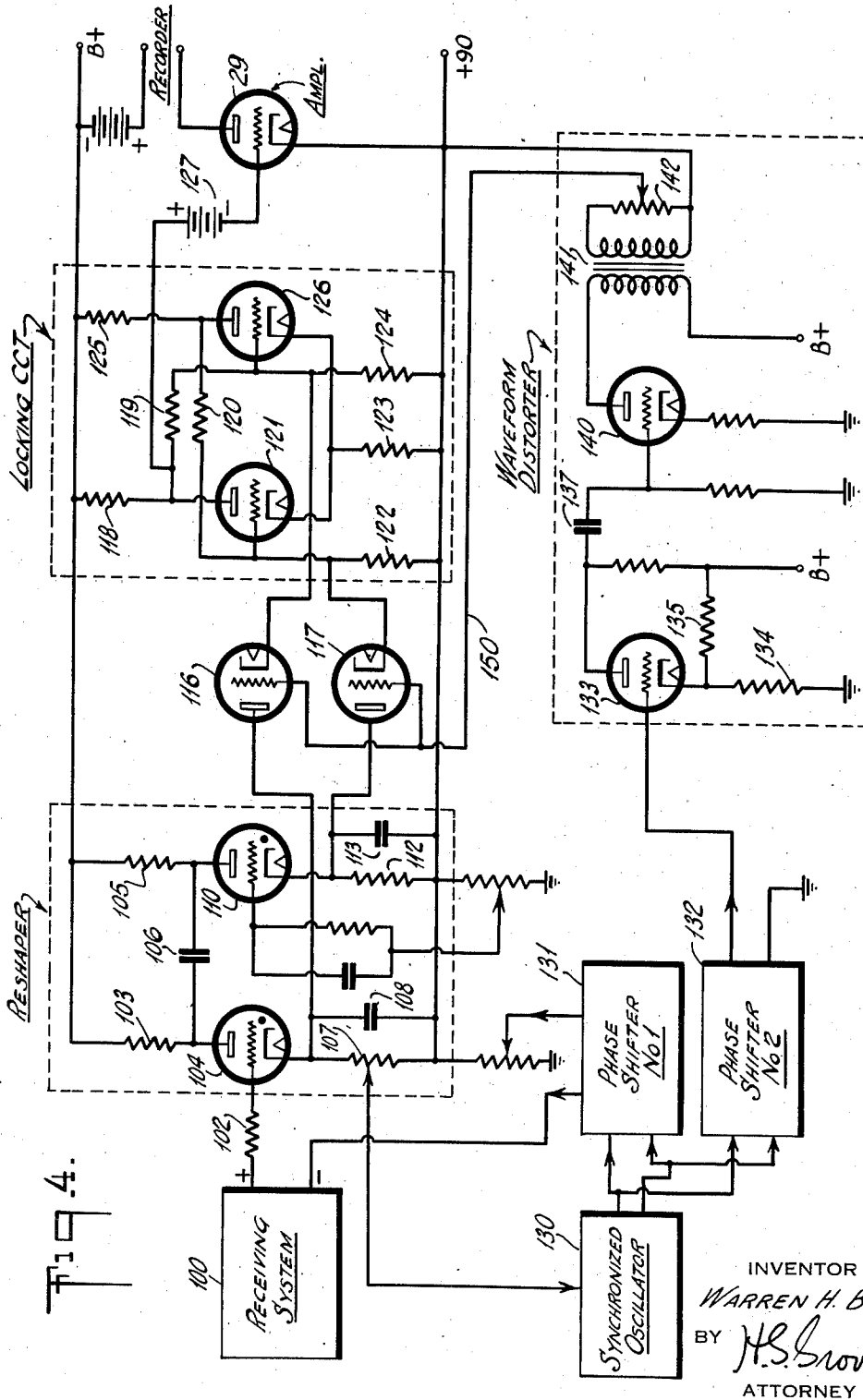
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PULSE TYPE TELEGRAPH RECEIVER

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5 Sheets-Sheet 3



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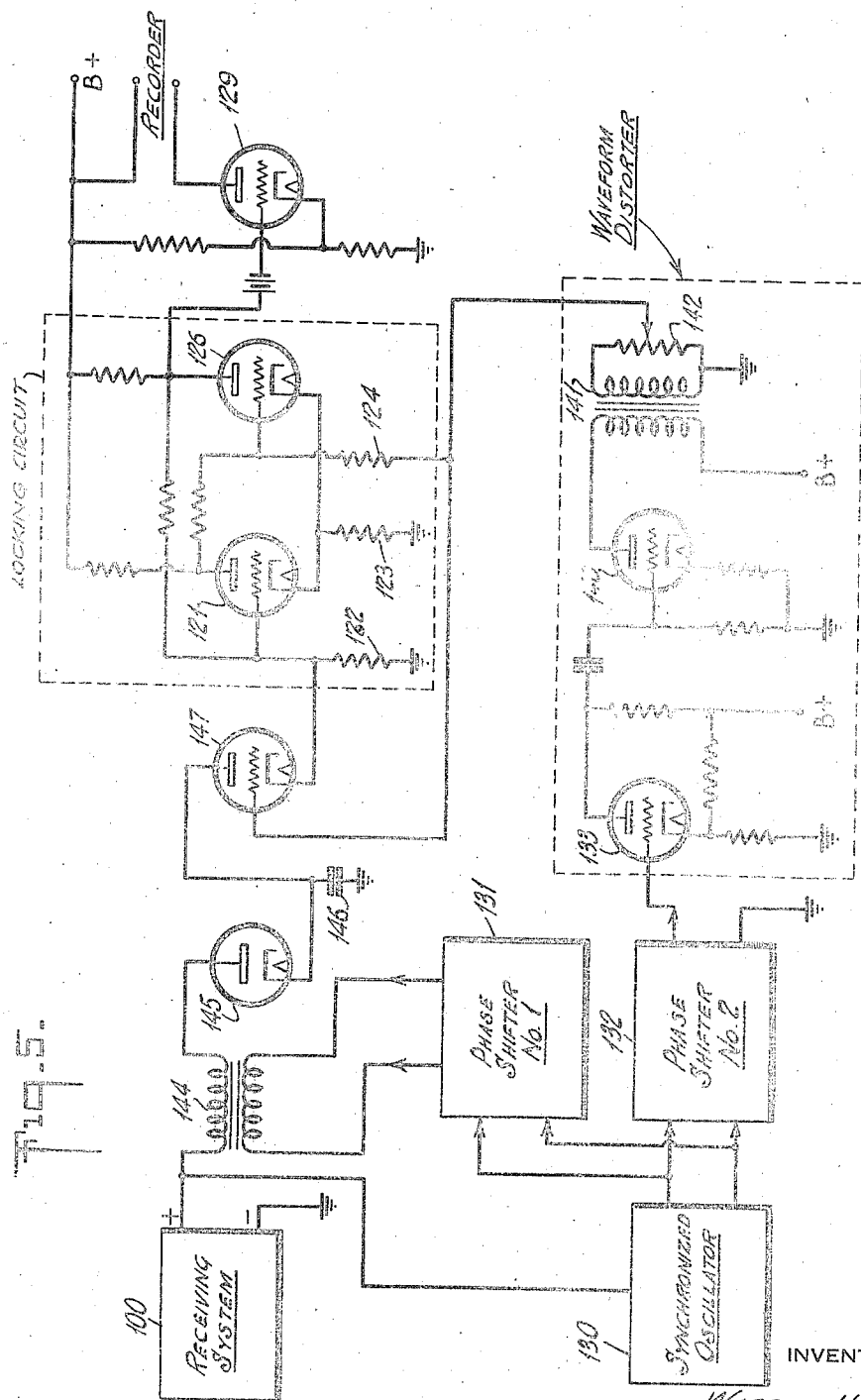
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PULSE TYPE TELEGRAPH RECEIVER

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5 Sheets-Sheet 4



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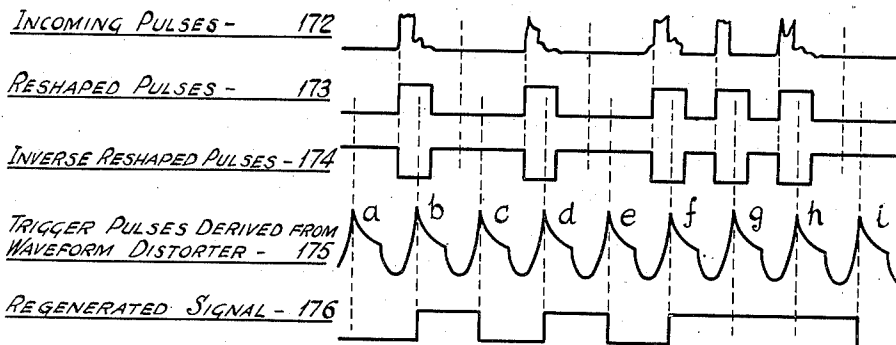
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Fig. 6.



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PULSE TYPE TELEGRAPH RECEIVER

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Application June 17, 1943; Serial No. 491,088

20 Claims. (Cl. 178—88)

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Radio telegraph systems employ either the conventional Morse code or the multi-unit printer code. The Morse code employs unequal length characters known as the dot and dash. The time duration of the dot is equal to the time duration of the baud which is the basic time unit, it being understood that the baud has a time duration of one-half a keying cycle at any speed. The time duration of the dash is equal to the time duration of three bauds or three basic time units. The multi-unit printer type signal, however, employs a plurality of equal length units each equal in time duration to the baud or basic time unit. As an example, a well known type of telegraph printer utilizes the constant length five unit printer code.

The present invention relates to a radio telegraph pulse communication system wherein a pulse whose duration is shorter than a dot is transmitted for each dot and three such pulses are transmitted for each dash. The remaining portions of the dots and dashes are suppressed at the transmitter, and the signal is reconstructed at the receiver from the received short pulses. One such system is described in my copending application, Serial #440,920, filed April 29, 1942, now U. S. Patent 2,365,450, granted December 19, 1944.

The present invention specifically relates to the receiving system for reconstructing or rebuilding the received short pulses into conventional length telegraph characters.

One object of the present invention is to provide an alternative and improved system for reconstructing received short pulses carrying telegraphic intelligence into conventional code characters.

Another object is to provide a receiving system for reconstructing short pulses of received energy into conventional code characters but which is ineffective or blocked during the intervals between the received pulses, so that spurious signals (such as from noise and interference) will not affect the operation of the receiver.

Since the receiving system of the present invention operates on the principle of pulses, the receiver is adjusted to operate at the same fundamental pulse frequency as the transmitter, and synchronized as to phase by the incoming pulses.

In accordance with one receiver embodiment of the invention, apparatus is provided for converting the received pulses into signals representing dots and dashes. The incoming pulses are applied to a two-tube gas triode reshaper. This reshaper operates on the arrival of each pulse

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and produces a solid square pulse irrespective of the shape of the received pulse. These reshaped pulses are then applied to a signal regenerator and also to a local controlled oscillator, and the reshaped pulses serve to synchronize this local oscillator. The regenerator converts the pulses back into Morse code dots and dashes, or multi-unit printer signals, by means of a two-tube vacuum triode locking circuit. An output tube coupled to the locking circuit supplies the regenerated or reconstructed signals to the recorder or printer. The local oscillator operates at the fundamental pulse frequency and its output, after proper amplitude and phase adjustments, is used for preventing noise peaks occurring between signal pulses from affecting the system and for tripping the tubes of the regenerator. In a modification of this embodiment, the local oscillator is also used for terminating the reshaped pulses.

In another embodiment of the invention, only vacuum tube circuits are employed to achieve the results of the invention, thus providing a more stable and simplified arrangement than that utilizing gaseous tubes.

Other objects of the invention will appear from a reading of the following description, which is accompanied by a drawing, wherein:

Fig. 1 illustrates one embodiment of a receiving system constructed in accordance with the principles of the present invention;

Fig. 2 illustrates in detail the phase shifting circuit employed in Fig. 1;

Fig. 3 illustrates a series of curves representing voltage variations at various designated points in the circuit of the receiver of Fig. 1;

Figs. 4 and 5 illustrate preferred forms of receiving systems of the invention; and

Fig. 6 illustrates a series of curves representing voltage variations at designated points in the circuits of the receivers of Figs. 4 and 5.

The complete radio telegraph receiving system of Fig. 1 includes essentially the following apparatus: A diversity receiver for collecting the incoming signals, a pulse reshaper fed by the diversity receiver, a vacuum tube locking circuit fed by the reshaper, and a local synchronized oscillator. The vacuum tube locking circuit is controlled both by the pulse reshaper and by the output of the oscillator through suitable phase shifting apparatus. The local oscillator is controlled as to phase by pulses from the pulse reshaper through a suitable low pass filter. The output circuit for the system, which may be any suitable utilization circuit, such as a recorder or printer,

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is coupled to the vacuum tube locking circuit through a suitable output coupling tube 34.

The diversity receiver is illustrative of any suitable standard continuous wave radio receiving system. It is shown as comprising a pair of geographically spaced antennas 1 and 2 separately feeding receivers 3 and 4 whose outputs are combined in a suitable combining unit 5. Receivers 3 and 4 may be of any suitable type, such as the superheterodyne receiver. The incoming signals in the form of short pulses are received on the antennas 1 and 2 and amplified, detected and combined in the apparatus 3, 4 and 5 in well known manner and the rectified signal pulses applied to the grid of tube 6 of the reshaper circuit through a current limiting resistor 8.

The term "reshaper" has here been employed because the circuit converts the shape of an initiating pulse applied to the grid of tube 6 into a substantially square or rectangular pulse irrespective of the shape of the received initiating pulse. More specifically, the "reshaper" comprises a pair of grid-controlled gaseous triode tubes 6 and 7 interconnected in the manner of a balanced or stable trigger circuit having two degrees of electrical stability and which requires an initiating pulse to change the condition of equilibrium. Gas tubes 6 and 7 are known in the art as "Thyratrons." These gas tubes have plate resistors 9 and 10 connecting the plates to a source of positive plate polarizing potential, and have cathode resistors 12 and 15. These cathode resistors are by-passed by condensers 13 and 16 which serve to improve the rectangular pulse wave form obtained from the reshaper. A commutating condenser 11 connects the plate of tube 6 to the plate of tube 7. Normally, gas tube 6 is non-conductive while gas tube 7 is conductive. The application of a signal or initiating pulse of positive polarity to the grid of tube 6 will cause this tube to conduct, as a result of which tube 7 will cease conducting by virtue of the commutating action of condenser 11. Putting it in other words, an initiating pulse will fire or trigger off the reshaper from one stable state in which tube 7 is normally conducting and tube 6 normally non-conductive to the other stable state in which the current passing conditions of these two tubes are reversed. Output energy from the reshaper in the form of square or rectangular wave pulses is taken from the cathode of tube 6 by way of lead 95 and applied both to the "vacuum tube locking circuit" through resistor 29 and to the low pass filter. The cathode of tube 7 is connected to the "vacuum tube locking circuit" through a resistor 17. The grid of tube 7 is connected through current limiting resistor 14 and phase shifter 21 to the sliding contact of potentiometer 19. Potentiometers 18 and 19 provide means for supplying and adjusting the grid bias on the triodes 6 and 7, respectively.

The "vacuum tube locking circuit," which can be referred to as a balanced trigger circuit, comprises a pair of vacuum tubes 27 and 31 whose grids and anodes are interconnected by means of resistors 25 and 26. Tube 27 is later referred to as the "space" tube, while tube 31 is later referred to as the "mark" tube. Plate resistors 23 and 24 connect the plates of tubes 27 and 31 respectively to the positive terminal of a source of plate polarizing potential B+. The cathodes of tubes 27 and 31 are connected together and directly to ground through a common ground potential bus 87. The grids of tubes 27 and 31 are connected through resistors 28 and 30, respectively, to phase

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shifter 22 and through this phase shifter to bias potentiometer 32. In effect, the locking circuit composed of the two tubes 27 and 31 has two degrees of electrical stability. These tubes are unstable when both are drawing current, but stable when one tube is passing current and the other tube locked or prevented from passing current. The change from one condition of stable equilibrium, such as when tube 27 is blocked and tube 31 is passing, to the other condition when tube 27 is passing and tube 31 blocked, or the reverse, is caused by the presence of a suitable predetermined potential applied to a grid of the locking circuit. This form of locking circuit is well known in the art, and a more detailed description of the general operation thereof may be had by referring to United States Patent #1,844,950, granted February 16, 1932, to James L. Finch. One characteristic of this locking circuit is that it remains in a particular condition of stability until such time as a pulse of suitable polarity impressed thereon serves to change the condition of electrical stability.

The local oscillator comprises a pair of amplifier tubes 47 and 55 arranged in a regenerative circuit. The grid of tube 55 obtains energy from the plate of tube 47 through blocking condenser 50 and in turn supplies feed-back energy from its plate to the grid of tube 47 through condenser 52 and resistor 51. The oscillatory circuit comprises an inductance coil 45 and a condenser 46 connected between the grid of tube 47 and the cathode, as shown. The plates of tubes 47 and 55 are supplied with positive polarizing potential through resistors 53 and 56, respectively, connected to the common plate supply lead extending to terminal B+. The oscillator is designed to produce oscillations of sine wave character and of an audio frequency which is the same as the fundamental pulse frequency of the transmitter. An oscillator of this general type is described in greater detail in United States Patent #2,162,520, granted to J. N. Whitaker, June 13, 1939, to which reference is made. The local oscillator is synchronized by means of pulses derived from the cathode of gas tube 6 of the "reshaper" and applied to lead 95. These synchronizing pulses, which are of rectangular shape, are fed to a low pass filter consisting of coil 65 and shunt-connected condensers 63 and 64 from which the filtered energy is supplied to an auxiliary amplifier tube 59 whose plate circuit is coupled to the grid of tube 55 of the local oscillator through a condenser 57. The low pass filter is terminated by resistors 62 and 66 of suitable values from an impedance matching standpoint. The cut-off frequency of the filter is arranged to be at a value slightly above the fundamental pulse frequency at which the local oscillator operates. Auxiliary amplifier tube 59 is provided with a plate resistor 58 connected to the positive terminal B+ of the source of plate polarizing potential and is also provided with a cathode resistor 61 shunted by a by-pass condenser 60. The low pass filter serves to remove most of the harmonic content of the essentially square pulses, and to change the shape of these square pulses to a resulting wave which is approximately sine wave in shape, and it is this last wave which is applied to tube 59.

The output of the local oscillator is applied to the grid of amplifier tube 42 having the usual cathode resistor 43 and shunt condenser 44. The plate circuit of tube 42 includes an audio frequency transformer 41 whose secondary winding

is coupled to the three phase shifters 20, 21 and 22.

The circuit of the phase shifters 20, 21 and 22 is shown in more detail in Fig. 2, which illustrates by way of example one form which these phase shifters may take. The phase shifter of Fig. 2 comprises an input transformer 68 whose primary winding is coupled to input terminals 67, an output transformer 74 whose secondary winding is coupled to output terminals 75, and a vacuum tube 71 coupled between the secondary winding of transformer 68 and the primary winding of transformer 74. The secondary winding of transformer 68 has one terminal connected to a variable resistor 70. Condenser 69 and resistor 70 are directly connected to a common lead extending to the grid of tube 71, as shown. The midpoint or center tap of the secondary winding of input transformer 68 is connected to the negative terminal of a battery or source of unidirectional potential 73, whose positive terminal is connected to the plate of tube 71 through the primary winding of output transformer 74. The cathode of tube 71 is also connected to the center tap of the secondary winding of input transformer 68 through a biasing resistor 72. The phase shifted output from the plate circuit of tube 71 appears at terminals 75.

These phase shifters are of the constant capacitance-variable series resistance type whose operation is familiar to those skilled in the art. By means of suitable values of capacitance and resistance for a given frequency, the output phase can be adjusted over a range of nearly 180° as the resistance is changed from its maximum value to zero. The magnitude of output of each phase shifter is determined by the turns ratio of the output transformer.

The regenerated or reconstructed code characters from the system of Fig. 1 are derived from terminals 31, one of which is connected to the cathode of the output coupling tube 34 whose grid is connected through resistor 33 to the plate of tube 27 of the locking circuit. Bias for the grid of coupling tube 34 is obtained from a tap on potentiometer 39 through an input resistor 35. The plate of vacuum tube 34 is connected directly to the positive terminal B+ of the source of plate polarizing potential.

It should be noted at this time that the lower terminals of potentiometers 18, 19, 32 and 39 are directly connected to the negative terminal of the stable source of unidirectional potential, while the upper terminals of these potentiometers are directly connected to ground by means of bus or common lead 87.

An understanding of the operation of the system of Fig. 1 may be had by referring to Fig. 3, which shows a series of curves 76 to 86, inclusive, representing voltage variations at various designated points in the system of Fig. 1. Let it be assumed that Morse code characters are being transmitted and that the dot frequency is 50 dot cycles per second. With this assumption, the fundamental pulse frequency is one hundred pulses per second, in which case the local oscillator 47, 55 will be arranged to produce sine wave oscillations of a frequency of one hundred cycles per second. The low pass filter 63, 64 and 65 will therefore be set at a value slightly above the fundamental pulse frequency of one hundred pulses per second, and should have a cut-off frequency of, let us say, 150 cycles per second. Let it also be assumed that the letter R in Morse code characters is being received. This letter R com-

prises a dot, a dash and a dot. At the transmitter, only a short pulse will be transmitted for each basic unit of the signal, so that the letter R will be transmitted in the form of a short pulse for the dot, three short spaced pulses for the dash, and another short pulse for the second dot of this letter. Curve or wave form 76 shows a typical incoming signal for the letter R as observed at the output terminals of the combining unit 5 of Fig. 1 for a pulse type telegraph system. The three pulses in the center constitute the dash of the letter R. A noise peak 89 is shown as appearing between the last two received pulses, that is, between the dash and the last dot. These incoming received pulses represented by curve 76 are applied directly to the grid of the gas triode 6 of the "reshaper," in combination with a blocking sine wave represented by curve 80, emanating from phase shifter 20. The combined wave or total electromotive force of both the incoming received signal and the output of the phase shifter 20 is represented by the wave form of curve 81. This wave form has been labeled E_{gs} , because it is the voltage wave applied to the grid of tube 6 of the "reshaper." Horizontal line 90 of wave form 81 represents the critical cut-off potential for gas tube 6 below which the tube remains in its normal state of non-conductivity and above which the tube 6 fires or triggers off to reverse the states of conduction of the two gas tubes 6 and 7. It will be seen from the curve 81 that the voltage wave applied to the grid of tube 6 rises above the cut-off value 90 at times corresponding to the times of the received signal pulses. Thus, the tube 6 will fire with the arrival of each received pulse to produce a rectangular or square wave output pulse represented by curve 77. The output of tube 6 (as indicated by curve 77) is derived from the cathode of tube 6 by way of lead 95.

It should be noted that wave form 76 includes a spurious signal at 89, representative of a noise or interference peak. This noise peak 89, however, will not cause a false firing of tube 6 because the combination thereof with the blocking electromotive force sine wave represented by curve 80 will produce a resultant whose position falls below the critical value, as shown in the combined wave form 81 at point 89. By proper adjustment of the phase and magnitude of this blocking wave constituting the output of the phase shifter 20, the effect of most of the received noise pulses is eliminated.

The firing or triggering of the "reshaper" by means of the pulses applied to the grid 6, reverses the states of conduction of the two gas tubes 6 and 7. The "reshaper" circuit will be restored to its original condition of equilibrium at a time interval shortly after the application of an initiating pulse to the tube 6 when a pulse of positive polarity is applied to the grid of tube 7 by the phase shifter 21. Curve 82 represents the wave form constituting the output of the phase shifter 21 which is applied through resistor 14 to the grid of gas tube 7. The output of phase shifter 21 fires the tube 7 and causes it to regain its normal condition of conduction soon after the arrival of such signal pulse. The output of gas tube 7 is taken from the cathode of this tube and is represented by curve 78. The square or rectangular wave obtained from gas tubes 6 and 7 and represented by curves 77 and 78 are of opposite polarity.

The output of the "reshaper," as obtained from lead 95 and represented by curve 77, is used to produce the regenerated or reconstructed signals

and to also control the synchronization of the local oscillator 47, 55. For this last purpose, the square wave pulses of curve 77 are applied to the grid of amplifier tube 59 via the single section low pass filter which, for the assumption of a fundamental pulse frequency of 100, should have a cut-off frequency of about 150 cycles per second. The resulting pulses from the output of the single section low pass filter which are approximately sine wave in shape, are amplified by tube 59 and then applied to the grid of the oscillator feed back tube 55 along with the normal amplified oscillations supplied from tube 47 of the oscillator. If the phase of the local oscillator thus tends to advance or retard, relative to the fundamental pulse frequency cycle, the incoming pulses automatically correct it.

Curves 80, 82 and 83 illustrate the wave forms of the outputs of phase shifters 20, 21 and 22, respectively, and their relative phases, while curve 79 represents the wave form output of the local oscillator. The relative phases of the outputs of these phase shifters are adjusted so that their associated circuit perform their intended functions properly. The "locking" circuit composed of interconnected tubes 27 and 31 serves to regenerate or reconstruct the incoming received pulses into full length code characters such as dots and dashes. The grid of "mark" tube 31 has applied to it the output of tube 6 through resistor 29 and represented by curve 77, combined with the output of phase shifter 22 through resistor 30 and represented by wave form 83. This combined wave form applied to the grid of tube 31 is represented by curve 84, and will cause the tube 31 to lock into a state of conduction whenever its grid potential rises above the critical value shown by the dotted horizontal line 91 of curve 84. This dotted line 91 represents the cut-off value of this tube. The tube 31 will start to conduct if it already is not in a state of conduction, and if it is in a state of conduction it will remain locked in this condition by the application of a potential to the grid of this tube above the critical value, until such time as the "space" tube 27 is caused to pass current. Tube 27 has applied to its grid the output of gas tube 7 through resistor 17 which has a wave form represented by curve 78, combined with the output of phase shifter 22 through resistor 28 and which has a wave form represented by the curve 83. This combined wave form of the voltage applied to the grid of the "space" tube 27 is represented by the curve 85. Tube 27 will take over control from the tube 31 and will pass current each time the grid voltage E_{g27} rises above the critical value shown by the dotted horizontal line 92 of curve 85.

By comparing the wave forms of curves 84 and 85, representing the voltages applied to the grids of tubes 27 and 31 respectively, and noting when they rise above their respective critical values, (shown by horizontal lines 91 and 92, respectively) it will be seen that tubes 31 and 27 of the locking circuit will produce a "mark" and "space" wave form as illustrated by curve 86. This curve 86 represents the fully regenerated or reconstructed wave form for the letter R and is actually produced as the variation in voltage at the plate of tube 27. The voltage of wave form 86 is applied to the grid of the output tube 34 through resistor 33 and the regenerated signal is taken from the cathode circuit of the coupling tube 34 by means of terminals 37 for subsequent utilization by a recorder or other suitable circuit.

Fig. 4 illustrates an embodiment of the inven-

tion which is more simplified than the system of Fig. 1, in employing, among other things, a more reliable arrangement for tripping the two-tube vacuum triode locking circuit. The system of Fig. 4 has the advantage over Fig. 1 of employing only two phase shifters. Referring to Fig. 4 in more detail, there is shown a receiving system 100 which represents any standard continuous wave radio receiving system whose output, taken with positive polarity, is applied to the "reshaper" comprising gas triodes 104 and 110. This "reshaper" is an unbalanced trigger circuit. The gas triodes 104 and 110 are supplied with cathode resistors 107 and 112 and with plate resistors 103 and 105, respectively. The cathode resistors 107 and 112 are by-passed by condensers 108 and 113, respectively. A commutating condenser 106 is connected between the plates of the two gas tubes. The outputs of the gas tubes 104 and 110, taken from their cathode circuits, are applied directly to the plates of vacuum triodes 116 and 117, whose grids are directly connected together. A portion of the output of gas tube 104 is also supplied to the synchronized oscillator 130, the filter and auxiliary tube being here omitted. The "reshaper" is a form of unbalanced or unstable trigger circuit in which tube 104 is normally non-conductive and tube 110 normally conductive. Tube 110 will hold its state of conduction except when an incoming pulse fires tube 104, in which case the current passing conditions of the two tubes will be reversed. After a time predetermined by the bias setting for tube 110, and the constants of the circuit, this tube will recover conduction and tube 104 will again become non-conductive. The "reshaper" serves to provide rectangular or square wave output pulses irrespective of the form of the incoming short pulses.

The oscillator 130 is substantially the same as that illustrated in Fig. 1 and provides an output which is fed into two conventional variable phase shifters 131 and 132 of the type previously described in connection with Fig. 2. The output of phase shifter 131 is supplied in series with the incoming signal to the grid 104 through resistor 102, and the output of phase shifter 132 is directed into a wave form distorting circuit consisting of vacuum triodes 133 and 140 interconnected as shown. A fixed bias is produced on tube 133 by means of resistors 134 and 135, and this tube is coupled by condenser 137 to the grid of tube 140 which operates as a class A amplifier. The output of tube 140 passes through a transformer 141 whose secondary winding is shunted by a potentiometer 142. A tap on potentiometer 142 feeds energy over lead 150 directly to the grids of both tubes 116 and 117.

The cathodes of tubes 116 and 117 are connected to circuit elements of a vacuum tube locking circuit comprising tubes 121 and 126. The anodes and grids of these two tubes of the locking circuit are interconnected by means of resistors 119 and 120. Grid resistors 122 and 124 are shown connected to the grids of tubes 121 and 126, respectively. A common cathode resistor 123 is provided for both tubes of the locking circuit. This locking circuit is also provided with plate resistors 118 and 125, both of which connect to the positive terminal B+ of a source of unidirectional plate polarizing potential. The locking circuit has two degrees of electrical stability, and functions generally in the manner of the locking circuit of Fig. 1. It should be noted that resistor 122 is common to the cathode of tube 117 and the grid of tube 121, and that resistor 124 is

common to the cathode of tube 116 and the grid of tube 126. The output of the locking circuit, taken from the plate of triode 121, is applied to a suitable utilization device, which may be a recorder, by means of a driver tube 29 whose grid is connected to the plate of tube 121 through a battery 127 which maintains proper bias on the grid of tube 29.

The operation of Fig. 4 will now be given with particular reference to the series of curves 172-176, inclusive, of Fig. 6. Incoming pulses, as illustrated by the wave form of curve 172 of Fig. 6, are applied to the control grid of gas tube 104, which produces a conduction versus time relationship as shown by the wave form of curve 173. The conduction versus time pattern of tube 110 is given by the wave form of curve 174 and is the inverse of the wave form of the curve 173. These curves 173 and 174 are developed as voltages across the cathode resistors 107 and 112, respectively, and they are also applied as the anode voltages to vacuum tube triodes 116 and 117, respectively. The oscillator 130 is maintained in synchronism with the incoming signals in the same manner as described in connection with Fig. 1, and the output of phase shifter 131 is used for noise blocking purposes, also in the same manner as explained above in connection with Fig. 1. The output of phase shifter 132 is clipped or limited by the vacuum tube 133, which is over-biased, and this output is further distorted by the intentionally poor response of transformer 141. The resultant wave form obtained from potentiometer 142 and applied to the grids of tubes 116 and 117 by way of lead 150, is shown in the wave form of curve 175. It should be noted that this wave form is very peaked for the purpose of reliably and quickly tripping the locking circuit.

The wave form 175, it should be noted, comprises a multiplicity of trigger pulses labeled *a* to *i*, inclusive, and these trigger pulses are applied simultaneously to the control grids of tubes 116 and 117 at the proper phase by virtue of the phase shifter unit 132. The outputs of tubes 116 and 117 consist of similarly sharp pulses developed across the cathode resistors 124 and 122 of the locking circuit. However, these output pulses, which become the input or tripping pulses for the locking circuit, do not occur simultaneously across both of the resistors 124 and 122 because of the distributed manner in which plate potential is supplied to triodes 116 and 117 by the "reshaper." Since the tube 116 receives plate potential only during the intervals indicated by the wave form or curve 173, it is evident that only pulses *b*, *d*, *f*, *g*, *h* of wave form 175 will be transferred on to the control grid of triode 126. Likewise, since tube 117 is supplied with plate potential, as indicated by the wave form of curve 174, only pulses *a*, *c*, *e* and *i* of wave form 175 will be applied to the grid of triode 121 of the locking circuit.

The functioning of triodes 121 and 126 is such that at any given instance one tube only conducts plate current while the other is driven to or beyond cut-off. A positive pulse applied to the grid of the non-conducting tube will "flip" or swing this tube into conduction and the other will be driven to cut-off. A positive pulse applied to the conducting tube will have no effect. A comparison of the wave forms of curves 173, 174 and 175 will show that tube 126 will have a conduction versus time characteristic as illustrated by the wave of curve 176, while tube 121 will have an inverse characteristic.

Wave form 176 is developed as the voltage variation at the plate of tube 121 and is used to drive the recorder or other utilization apparatus by means of amplifier tube 29 and represents the regenerated or reconstructed code signal of the remote transmitter.

Fig. 5 is a modification of the system of Fig. 4. The boxes of both of these figures which are similarly labeled contain apparatus which function similarly to those of Fig. 4, except for certain slight differences which will be pointed out later.

Referring to Fig. 5 in more detail, the output of the receiving system 100 is supplied through a half wave rectifier 145 to a condenser 146, and also supplied directly to the oscillator 130 for synchronizing purposes. The two phase shifters 131 and 132 are the same as those of Fig. 4, except that the output of phase shifter 131 is fed in series through the secondary winding of transformer 144 to provide the desired noise blocking effect between impulses in the charging circuit of the condenser 146. The output of phase shifter 132 is fed to the wave form distorting circuit composed of vacuum tube triodes 133 and 140. This part of the circuit is also similar to that of Fig. 4, except that its output from transformer 141 is fed through potentiometer 142 to the grid of vacuum triode 147, and also through a resistor 124 to the grid of tube 126. The discharge circuit for condenser 146 is through triode 147 and resistor 122. Resistor 122 is also the grid input resistor for triode 121 which operates in conjunction with triode 126 as a locking circuit. The remainder of the locking circuit with the driver tube 129 is substantially the same as that of Fig. 4.

A description of the operation of the system of Fig. 5 follows: The incoming pulses represented by the wave form of curve 172 of Fig. 6 are allowed to charge condenser 146 through rectifier 145, provided at the time of the incoming pulses the sine wave output of phase shifter 131 is at its positive peak value. In other words, the positive peak of the output of phase shifter 131 adds with the incoming pulse to provide a resultant wave whose peak exceeds the value necessary to operate rectifier 145. Shortly after the arrival time of each of these incoming pulses, the condenser is discharged through triode 147 through the application of a peaked pulse from the transformer 141. These peaked or trigger pulses are shown as the wave form of curve 175 of Fig. 6. Since the discharging of condenser 146 takes place through resistor 122, a tripping pulse will be passed on to tube 121 of the locking circuit for each incoming pulse. Conduction will be switched each such time from tube 126 to tube 121, if the former is not already in a state of conduction, in which case, if it is in a state of conduction, it will remain so. The bias for triode 147, while tube 126 is conducting, is obtained as the IR drop across resistor 122 and is sufficient to prevent the discharge of condenser 146 prematurely. The trigger pulses of curve 175 are also applied to the grid of tube 126 at lesser magnitude than those applied to tube 121 because of the series resistor 124. Hence, at the periods when no discharge of condenser 146 takes place (no incoming pulses having been received), tube 126 will be tripped by the trigger pulses and it will take conduction from tube 121. Reference to wave form 172 and 175 of Fig. 6 reveals that condenser 146 will receive charges just preceding trigger pulses *b*, *d*, *f*, *g*, and *h* and will be dis-

charged by these trigger pulses so as to trip tube 121 of the locking circuit or keep it tripped as in the case of pulses *g* and *h*. These same pulses *b*, *d*, *f*, *g* and *h* are also applied to the tube 125 through resistor 124 but have no effect here since the simultaneously applied pulses at tube 121 predominate. However, the trigger pulses *a*, *c*, *e* and *i* will be effective in tripping tube 125. The results of the above switching combinations will give a conduction versus time characteristic for tube 121 as shown by wave form 176 of Fig. 6. Thus, the regenerated signal and its voltage variation is selected from the plate of tube 125 to operate the recorder or other utilization device through the driver tube 129. Since most noise peaks are shorter in duration than the regular incoming pulses, it is preferred (in the operation of the system of Fig. 5) to so adjust condenser 146 in size as to absorb such peaks without developing a high enough voltage to cause false tripping of the locking circuit.

What is claimed is:

1. In a pulse communication system, a receiver having means for collecting the incoming pulse signals, an electron tube trigger circuit, an audio frequency oscillator operating at the fundamental pulse frequency, means for combining the output of said local oscillator with the output of said receiver and applying the resultant wave to said trigger circuit, said means including a phasing circuit, and means for synchronizing said oscillator from said trigger circuit.

2. In a pulse receiving system, an electron tube trigger circuit, a generator of oscillations operating at the fundamental pulse frequency, means for applying the incoming pulses and the output of said generator to said trigger circuit, said means including a phasing circuit for assuring that the positive peaks of output from said generator combine with the incoming pulses to produce a resultant wave form whose positive peaks exceed the critical value required to change the condition of electrical stability of said trigger circuit, a locking circuit in the form of a pair of vacuum tubes so interconnected as to have two degrees of electrical stability, and individual connections from the electron tube trigger circuit to said vacuum tubes for controlling said locking circuit in dependence upon the condition of electrical stability of said trigger circuit.

3. In a radio telegraph signal receiving system for receiving pulses representative of intelligence signals transmitted from a remotely located radio transmitter, an unbalanced trigger circuit having only one degree of electrical stability, said trigger circuit comprising first and second gaseous grid-controlled tubes so interconnected that only one of said tubes is conductive at any one time, said first tube being normally conductive and said second tube being conductive for only a short period after an initiating pulse is applied to said trigger circuit, a sine wave oscillator operating at the fundamental pulse frequency, and means for combining the sine wave output of said oscillator and unidirectional pulses representative of the received pulses to control said trigger circuit, said means including a phasing circuit for assuring that the peaks of predetermined polarity of the sine waves combine in phase with the polarity of the unidirectional pulses.

4. In a radio receiving system for receiving pulses of energy representative of intelligence signals transmitted from a remotely located radio transmitter, an electron tube trigger circuit of

the double stability type always requiring the application thereto of a wave of predetermined polarity to change the condition of stability for converting the incoming pulses to rectangular wave pulses, a generator of sine wave oscillations operating at the fundamental pulse frequency, and means for combining said sine wave oscillations and the incoming pulses and for applying the resultant wave to said trigger circuit, said means including a phasing circuit having a range of substantially 180° for assuring that only the peaks of positive polarity of said sine wave oscillations are combined in phase with the incoming pulses to produce resultant peaks having a value exceeding the critical value required to fire said trigger circuit.

5. In a pulse receiving system, an electron discharge device trigger circuit for converting the incoming pulses to rectangular wave pulses, said trigger comprising a pair of grid-controlled gaseous tubes so interconnected that only one of said tubes is conductive at any one time, a generator of sine wave oscillations operating at the fundamental pulse frequency, means for combining said sine wave oscillations and the incoming pulses and for applying the resultant wave to the grid of that tube which is normally non-conductive to thereby alter the condition of electrical equilibrium of said trigger circuit, and a circuit for applying the sine wave oscillations of said generator to the grid of the normally conductive tube to restore the normal condition of equilibrium of said trigger circuit, said last circuit including a phase shifter.

6. In a pulse receiving system, a trigger circuit for converting the incoming pulses to rectangular wave pulses, said trigger circuit comprising a pair of grid-controlled gaseous tubes so interconnected that only one of said tubes is conductive at any one time, a generator of sine wave oscillations operating at the fundamental pulse frequency, means for combining said sine wave oscillations and the incoming pulses and for applying the resultant wave to the grid of that tube which is normally non-conductive to thereby alter the condition of electrical equilibrium of said trigger circuit, said means including a phase shifter for assuring that the positive peaks of said sine wave oscillations combine in phase with the incoming pulses to produce resultant waves with peaks having values exceeding the critical value required to change the normal condition of equilibrium of said trigger circuit, and a circuit for applying the sine wave oscillations of said generator to the grid of the normally conductive tube to restore the normal condition of equilibrium of said trigger circuit, said last circuit including a phase shifter.

7. A system as defined in claim 7, including another trigger circuit having two degrees of electrical stability, said last trigger circuit including a pair of vacuum tubes having their grids and anodes interconnected so that only one vacuum tube is conductive at any one time, separate connections from the grids of said vacuum tubes to the outputs of said gaseous tubes of said first trigger circuit, and means for supplying the grids of said vacuum tubes with sine wave oscillations from said generator through still another phase shifter.

8. In a pulse receiving system, an unbalanced trigger circuit for converting the incoming pulses to square wave pulses, said trigger comprising a pair of grid-controlled gaseous tubes so interconnected and biased as to have only one degree

of electrical stability, one of said gaseous tubes being normally conductive and the other tube normally non-conductive, a generator of oscillations of a frequency equal to the fundamental pulse frequency, means including a phase shifter for combining said oscillations with the incoming pulses and for applying the resultant wave to the grid of the normally non-conductive tube to thereby alter the condition of electrical stability of said trigger circuit, the constants of said trigger circuit being such that said trigger circuit restores itself to normal after a predetermined time interval, a pair of vacuum tubes each having plate, grid and cathode electrodes, connections from the plates of said vacuum tubes to different outputs of said gaseous tubes, whereby said plates obtain at different times from said trigger circuit the polarizing potentials necessary to enable the vacuum tubes to conduct current, and means including a phase shifter coupling the grids of said vacuum tubes in common to said generator.

9. In a pulse receiving system, an unbalanced trigger circuit for converting the incoming pulses to rectangular wave pulses, said trigger circuit comprising a pair of grid-controlled gaseous tubes so interconnected and biased as to have only one degree of electrical stability, one of said gaseous tubes being normally conductive and the other tube normally non-conductive, a synchronized generator of sine wave oscillations of a frequency equal to the fundamental pulse frequency, means including a phase shifter for combining said oscillations with the incoming pulses in such phase that the positive peaks of the sine wave oscillations add with incoming pulses to produce a resultant wave form whose peaks exceed the critical value required to fire said trigger circuit, and for applying the resultant wave to the grid of the normally non-conductive tube to thereby alter the condition of electrical stability of said trigger circuit, the constants of said trigger circuit being such that said trigger restores itself to normal after a predetermined time interval, a pair of vacuum tubes each having plate, grid and cathode electrodes, connections from the plates of said vacuum tubes to different outputs of said gaseous tubes, whereby said plates obtain at different times from said trigger circuit the polarizing potentials necessary to enable the vacuum tubes to conduct, and means including a phase shifter coupling the grids of said vacuum tubes in common to said generator.

10. In a pulse receiving system, a generator of oscillations operating at the fundamental pulse frequency, a storage element, a rectifier coupled to said storage element, means for applying the incoming pulses to said rectifier including a transformer, means including said transformer and a phase shifter for applying said oscillations to said rectifier, a space discharge circuit for said storage element, and means including a wave distorter coupling the output of said generator to said space discharge circuit for applying periodically recurring peaked waves to said discharge circuit at the frequency of said generator, and an electron tube trigger circuit coupled to said space discharge circuit and responsive to the flow of current therethrough.

11. In a pulse receiving system, a synchronized generator of oscillations of sine wave form operating at the fundamental pulse frequency, a storage condenser, a rectifier coupled to said storage condenser, means for applying both the

incoming pulses and output energy from said generator to said rectifier, said means including a phase shifter for assuring that the positive peaks of said oscillations additively combine with incoming pulses to increase the resultant rectified stored energy on said condenser, a discharge path for said condenser comprising a vacuum tube having a control electrode, and a circuit for rendering said vacuum tube conductive shortly after the arrival of each incoming pulse, said circuit including a phase shifter coupled to the output of said generator, a wave distorter whose input is coupled to said phase shifter and whose output is coupled to the control element of said vacuum tube, said wave distorter altering the sine waveform of the oscillations impressed thereon to a wave form having accentuated peaks recurring at the frequency of said generator.

12. In a pulse type communication system wherein pulses are transmitted whose time duration is shorter than that of the pulse corresponding to one-half a keying cycle, a receiving system including signal regenerator receiver for rebuilding the received pulses into longer time duration units, said receiver comprising a local oscillator producing sine wave oscillations synchronized by the incoming pulses and operating at the fundamental pulse frequency, a balanced electronic trigger locking circuit under control of both the incoming pulses and the output of said oscillator, said trigger circuit comprising a pair of vacuum tubes so interconnected and biased that when one tube passes current the other tube is blocked, and vice versa, said trigger circuit having two degrees of electrical stability and always requiring the application thereto of a waveform of predetermined polarity to change the condition of stability, and a vacuum tube phase shifter having a range of approximately 180° located between the sine wave output of said oscillator and the input to said trigger circuit, as a result of which oscillations of sine wave form are applied to said trigger circuit.

13. In a pulse receiving system, an unbalanced trigger circuit for converting the incoming pulses to rectangular wave pulses, said trigger circuit comprising a pair of grid-controlled gaseous tubes so interconnected and biased as to have only one degree of electrical stability, one of said gaseous tubes being normally conductive and the other tube normally non-conductive, a synchronized generator of sine wave oscillations of a frequency equal to the fundamental pulse frequency, means including a phase shifter for combining said oscillations with the incoming pulses in such phase that the positive peaks of the sine wave oscillations add with incoming pulses to produce a resultant wave form whose peaks exceed the critical value required to fire said trigger circuit, and for applying the resultant wave to the grid of the normally non-conductive tube to thereby alter the condition of electrical stability of said trigger circuit, the constants of said trigger being such that said trigger circuit restores itself to normal after a predetermined time interval, a pair of vacuum tubes each having plate, grid and cathode electrodes, connections from the plates of said vacuum tubes to different outputs of said gaseous tubes, whereby said plates obtain at different times from said circuit the polarizing potentials necessary to enable the vacuum tubes to conduct current, and a wave distorter, and means including a phase shifter coupling the grids of said vacuum tubes.

in common to said generator, through said wave distorter.

14. In a pulse receiving system, a synchronized generator of oscillations of sine wave form operating at the fundamental pulse frequency, a storage condenser, a rectifier coupled to said storage condenser, means for applying both the incoming pulses and output energy from said generator to said rectifier, said means including a phase shifter for assuring that the positive peaks of said oscillations additively combine with incoming pulses to increase the resultant rectified stored energy on said condenser, a discharge path for said condenser comprising a vacuum tube having a control electrode, a circuit for rendering said vacuum tube conductive shortly after the arrival of each incoming pulse, said circuit including a phase shifter coupled to the output of said generator, a wave distorter whose input is coupled to said phase shifter and whose output is coupled to the control element of said vacuum tube, said wave distorter altering the sine wave form of the oscillations impressed thereon to a wave form having accentuated peaks recurring at the frequency of said generator, an electron discharge device locking circuit under control of said vacuum tube, and recording apparatus coupled to an output electrode of said locking circuit.

15. In a pulse receiving system, a generator of oscillations operating at the fundamental pulse frequency, a storage element, a rectifier coupled to said storage element, means for applying the incoming pulses to said rectifier including a transformer, means including said transformer and a phase shifter for applying said oscillations to said rectifier, a space discharge circuit for said storage element, and means including another phase shifter and a wave distorter coupling the output of said generator to said space discharge circuit for applying periodically recurring peaked waves to said discharge circuit at the frequency of said generator, and an electron tube trigger circuit coupled to said space discharge circuit and responsive to the flow of current therethrough.

16. A pulse receiving system for rebuilding the received pulses into longer duration units comprising a rectangular wave producing pulse reshaper of the trigger type upon which the received pulses are impressed, a synchronized oscillator, connections for superimposing the output from said oscillator upon the received pulses applied to said reshaper, to thereby produce a resultant wave form whose peaks of a predetermined polarity during actual reception of the incoming pulses exceed the critical value necessary to operate said reshaper, means for producing marking and spacing pulses from the reshaped pulses, said means including a balanced trigger circuit having two degrees of electrical stability, and connections for supplying the input of said balanced trigger circuit from the output of said reshaper under control of the synchronized oscillator.

17. In a pulse receiving system, a synchronized generator, a storage condenser, a rectifier coupled to said storage condenser, means for applying both the incoming pulses and output energy from said generator to said rectifier, said means including a phase shifter for assuring that the peaks of the output waves from said generator additively combine with incoming pulses to increase the resultant rectified stored energy on said condenser, a discharge path for said condenser comprising a vacuum tube having a control electrode, and a circuit for rendering said vacuum tube conductive shortly after the arrival

of each incoming pulse, said circuit including a wave distorter whose input is coupled to said generator and whose output is coupled to the control electrode of said vacuum tube, said wave distorter altering the wave form of the generated waves impressed thereon to a wave form having accentuated peaks recurring at the frequency of said generator.

18. In a pulse receiving system, a synchronized generator of oscillations of sine wave form operating at the fundamental pulse frequency, a storage condenser, a rectifier coupled to said storage condenser, means for applying both the incoming pulses and output energy from said generator to said rectifier, said means including a phase shifter for assuring that the positive peaks of said oscillations additively combine with incoming pulses to increase the resultant rectified stored energy on said condenser, a discharge path for said condenser comprising a vacuum tube having a control electrode, and a circuit for rendering said vacuum tube conductive shortly after the arrival of each incoming pulse, said circuit including a phase shifter coupled to the output of said generator, a wave distorter whose input is coupled to said phase shifter and whose output is coupled to the control element of said vacuum tube, said wave distorter altering the sine wave form of the oscillations impressed thereon to a wave form having accentuated peaks recurring at the frequency of said generator, and means for producing marking and spacing pulses from the rectified energy stored on said storage condenser, said last means including a balanced electron discharge device trigger circuit having an input circuit coupled to an electrode of said vacuum tube.

19. In a pulse type communication system wherein pulses are transmitted whose time duration is shorter than that of the pulse corresponding to one-half a keying cycle, a signal regenerator receiver for rebuilding the received pulses into longer time duration units, said receiver comprising a local oscillator producing sine wave oscillations synchronized by the incoming pulses and operating at the fundamental pulse frequency, an electronic trigger locking circuit having two degrees of electrical stability, a wave reshaper coupling the output of said receiver to said locking circuit, a phase shifter coupling the output of said local oscillator to said locking circuit, whereby said locking circuit is under control of both said wave reshaper and the output of said oscillator.

20. In a radio telegraph receiving system for receiving pulses representative of intelligence signals transmitted from a remotely located radio transmitter, an electron tube trigger circuit, a generator of sinusoidal oscillations operating at the fundamental pulse frequency, a circuit including a low pass filter for controlling said generator from the output of said trigger circuit, and means for applying unidirectional pulses representative of the received pulses and the sine wave output of said generator to said trigger circuit, said means including a phasing circuit for assuring that the positive peaks of sine wave output from said generator combine with the unidirectional pulses to produce a resultant wave form whose positive peaks exceed the critical value required to change the condition of electrical stability of said trigger circuit.

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(References on following page)

2,457,974

17

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
1,844,950	Finch -----	Feb. 16, 1932
2,053,044	Pierson -----	Sept. 1, 1936
2,061,734	Kell -----	Nov. 24, 1936
2,262,838	Deloraine -----	Nov. 18, 1941

5

10

18

Number	Name	Date
2,272,070	Reeves -----	Feb. 3, 1942
2,333,281	Wilder -----	Nov. 2, 1943
2,406,019	Labin -----	Aug. 20, 1946

OTHER REFERENCES

American Standard Definitions of Electrical Terms published by A. I. E. E., page 203, section 65.10.435 and page 229, 65.65.500, copy in Division 16.