

Jan. 19, 1943.

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2,308,639

SIGNALING AND COMMUNICATION SYSTEM

Filed Aug. 22, 1940

2 Sheets-Sheet 1

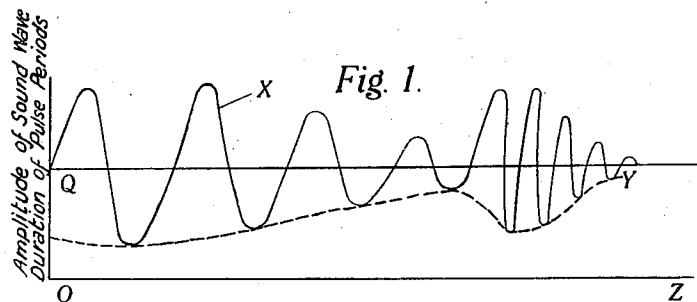


Fig. 1.

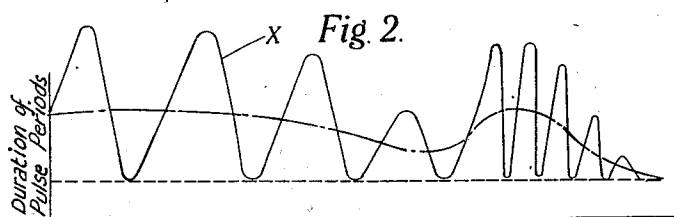


Fig. 2.

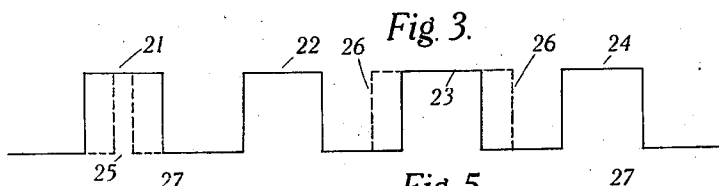


Fig. 3.

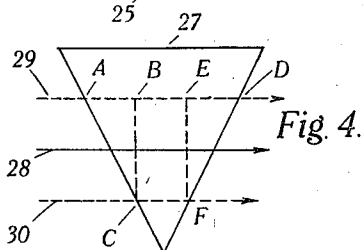


Fig. 4.

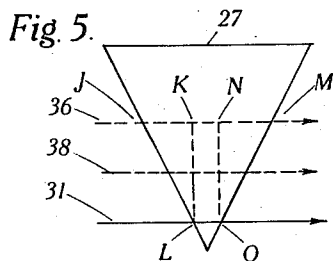


Fig. 5.

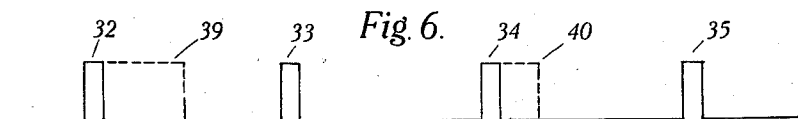


Fig. 6.

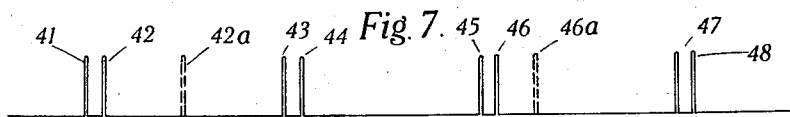


Fig. 7.

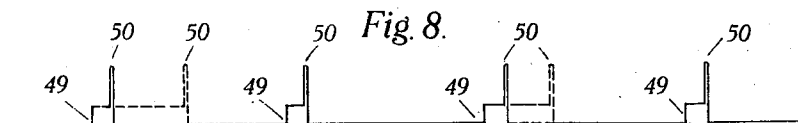


Fig. 8.

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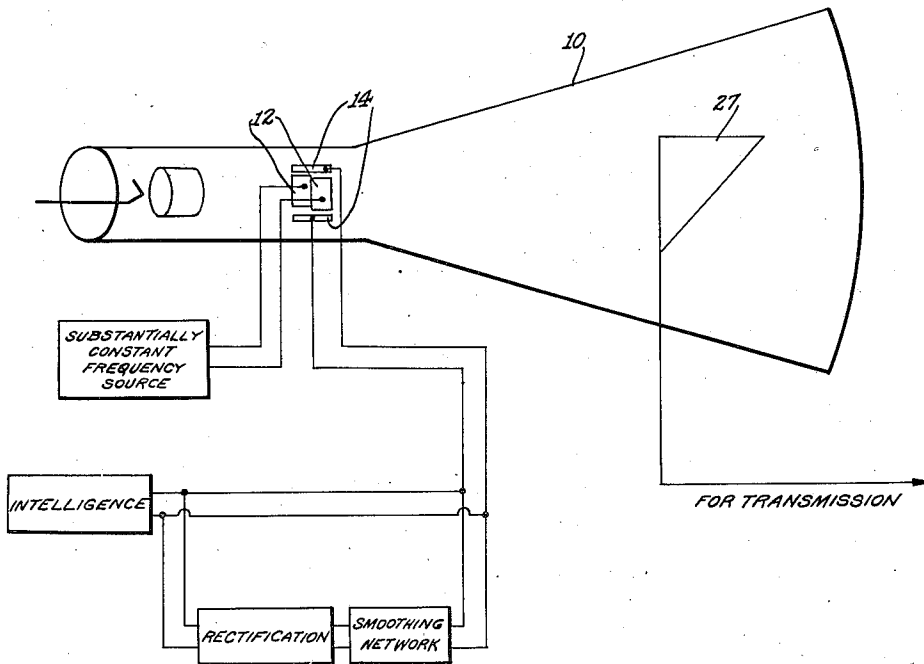
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FIG. 9.



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SIGNALING AND COMMUNICATION SYSTEM

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Application August 22, 1940, Serial No. 353,687
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2 Claims. (Cl. 179—171.5)

This invention relates to electrical signaling and communication systems which utilise for the transmission and reception of intelligence a train or trains of pulses having a time function which is characteristic of a sound or like wave, said train or trains of pulses for the purpose of convenience being referred to as time modulated pulses.

In the co-pending patent applications of William Arnold Beatty, Serial Nos. 313,041 filed January 9, 1940 (now U. S. Patent No. 2,256,336, granted September 16, 1941), and 312,645 filed January 6, 1940, there are described various types of time modulated pulses, these types including pulses coded as RS (rectangular symmetrical), RL (rectangular, leading edge fixed), RT (rectangular, trailing edge fixed), D/RL (double pulse rectangular, leading edge fixed), D/RT (double pulse rectangular, trailing edge fixed), RT+S/RT (rectangular, trailing edge fixed+double pulse rectangular, trailing edge suppressed) and RL+S/RL (rectangular, leading edge fixed+double pulse, leading edge suppressed). One object of the present invention is to convey intelligence by means of RS, RL, RT, RT+S/RT or RL+S/RL pulses with considerable economy in power, as compared with previously known methods, while a further object of the proposal is when using D/RL, D/RT, RT+S/RT or RL+S/RL pulses for the purpose of conveying intelligence, to so time modulate the pulses that in conjunction with known receiving circuits an improved signal to noise ratio is achieved.

The various types of time-modulated pulse trains have this in common, that the train defines a succession of periods or time intervals which vary in duration according to the successive instantaneous amplitudes of the original signal, i. e. of the sound or like wave. In some cases these periods are defined by the duration of the pulses themselves; in other cases by the intervals between pairs of pulses or between pulses and instants equally spaced in time.

In accordance with the present invention the periods defined by the pulses and corresponding to signal amplitudes are given a mean duration which fluctuates in accordance with mean signal amplitude. The periods preferably have a duration which varies upwardly from a substantially fixed minimum value.

The invention will be more fully described with reference to the accompanying drawings in which:

Figs. 1 and 2 are graphs used in explaining the underlying principles of the invention;

Fig. 3 shows a train of RS pulses with different modulation characteristics. Fig. 4 shows a target plate being scanned in a known manner;

Fig. 5 shows the same target plate scanned in accordance with D. C. time modulation requirements of the present invention;

Fig. 6 shows a train of pulses, some of which are D. C. time modulated;

Fig. 7 shows a train of double pulses derived from the pulses shown in Fig. 6;

Fig. 8 shows a train of RL—S/RL pulses derived from the pulses shown in Fig. 6; and

Fig. 9 diagrammatically illustrates a circuit arrangement for carrying out D. C. time modulation according to the present invention.

Referring to Fig. 1, curve X on axis QY represents a signal wave constituting intelligence which it is desired to transmit. It is an oscillation of varying amplitude and frequency, but can be completely defined by its amplitude at successive instants.

A time-modulated pulse train corresponding to such a signal wave marks out a succession of periods proportional to the amplitude of the signal wave at the successive instants. It thus completely defines the form of the signal wave. It also follows that this time-modulated pulse train can be represented by the curve X on axis OZ if the ordinates measure the duration of the periods defined by the pulses (for brevity, the duration of the pulse periods).

Hitherto the duration of the pulse periods has, as shown in Fig. 1, been varied above and below the mean value represented by the line QY, the minimum duration varying with the mean amplitude of the signal as shown by the dotted line.

It is now proposed to vary the mean duration in accordance with mean signal amplitude to equalise the minimum or maximum values. As shown in Fig. 2 the mean duration (chain dotted line) is preferably such that the minimum value (dotted line) is constant. For this purpose it is necessary in general to ensure that the mean amplitude or amplitude level of the alternating current signal wave which is used for deriving the time-modulated pulse train varies with respect to a fixed datum in accordance with the amplitude range of the signal. This may be done by rectifying the signal wave, passing the rectified output through a circuit of suitable time constant to give a voltage fluctuating in accordance with signal level, and imposing this voltage upon the signal wave to give it a fluctuating mean effective current component. Other methods of restoring the D. C. component used in television systems

may be employed and in the case of television systems the vision signal can be utilised without modification provided that the D. C. components are retained. A wave of suitably fluctuating level is also obtained if the signal is amplified in a class B or class C amplifier, since the D. C. output of such amplifiers is dependent upon signal amplitude.

As already indicated, previously known pulse modulation systems depend, for their operation, on a train of pulses being time modulated in such a manner that the duration of a pulse is increased above a normal duration for an increase in signal amplitude, and decreased below said normal duration for a decrease in signal amplitude. Such pulse modulation is illustrated in Fig. 3 of the accompanying drawings.

Referring to Fig. 3, there is shown by means of solid lines a train of RS pulses 21, 22, 23 and 24; these pulses are substantially rectangular in shape, each pulse having a duration which is equal to the interval between successive pulses. Intelligence characteristics of the amplitude of a sound or like wave can be obtained by time modulating such a pulse train, such time modulation being shown by the dotted lines 25 inside pulse 21, illustrating the condition when said pulse has a duration characteristic of a low amplitude signal intensity, while the dotted lines 26 outside pulse 23 illustrate the condition when this pulse has a duration characteristic of a high amplitude signal intensity. It will be seen that the time modulation of the pulse can be considered as the cyclical contraction and expansion of pulses in the train, said pulses in the unmodulated condition having durations shown by the heavy lines in Fig. 3. One method of generating and time modulating RS pulses is described in the aforementioned Patent 2,256,336, having reference to Fig. 4 of the drawing of said patent.

Referring to Fig. 4 of the accompanying drawings, there is shown a collector plate 27 similar to the collector plate 24 of the above-mentioned Fig. 4. As described in the aforementioned patent, the train of pulses shown in Fig. 3 is generated by the linear scanning of the plate 27 along the line 28. If now the beam is transversely modulated under the influence of a sound or like wave to such an extent as to move between the dotted lines 29 and 30, the intelligence due to modulation is a function of the area of the triangles ABC and DEF. Time modulation of pulses in the manner indicated above, will for the purpose of convenience be referred to as A. C. time modulation, i. e. modulation above and below a definite time duration.

In order to achieve the objects of the present invention a new kind of time modulation is utilised; this new modulation will for the purpose of convenience be referred to as D. C. time modulation, and can be more readily understood by referring to Fig. 5.

Referring to Fig. 5, the plate 27 is linearly scanned along the line 31 thus generating a train of short pulses 32, 33, 34 and 35, as shown in Fig. 6. If a similar value of transverse D. C. modulation is applied to the beam as represented by the peak value of the A. C. modulation utilised as shown in Fig. 4, the beam can now be made to move between the lines 31 and 36. The distance between the lines 31 and 36 being the same as the distance between the lines 29 and 30.

Assuming that the modulation is such that the beam moves between the limits shown by the lines 36 and 31, the pulse duration will have a mean

duration shown by the line 38 midway between the lines 31 and 36.

Referring to Fig. 6, the pulse 32 is shown by dotted lines extended to point 39, this duration of pulse corresponding to the condition when the plate 27 is being scanned along the line 36. The pulse 34 is also shown extended by dotted lines to point 40, this duration of pulse corresponding to the condition when the plate 27 is being scanned along the line 38.

The triangles JKL and MNO are similar in areas to the ABC and DEF, and as the intelligence due to modulation is a function of the area of these triangles, it can be seen that the same intelligence can be transmitted by the A. C. time modulation of a pulse of comparatively long duration or the D. C. time modulation of a pulse of comparatively short duration, provided that in the latter case the time modulation is in the positive sense, i. e. the duration of pulses increases above normal for any modulation.

The D. C. time modulation above described utilises an average power which is a function of the depth of modulation, and when applied to the modulation of a carrier wave gives practically all the advantages of a suppressed carrier or floating carrier system.

D. C. time modulation of pulses can be applied with advantage to all previously known A. C. time modulated pulse systems. The necessary modifications to these previously known pulse generating circuits should now (having reference to the foregoing) be obvious to those skilled in the art. For the sake of clarity we have diagrammatically indicated in Fig. 9 an arrangement for securing D. C. time modulation in accordance with the present invention. A tube 10 of suitable well-known type is provided with two sets of deflection plates 12 and 14. A suitable substantially constant frequency source may be connected to the deflecting plate 12, while the intelligence to be transmitted is applied to the deflecting plate 14 with the assistance of a suitable modulating control which may include a rectifier circuit and a smoothing network derived from the intelligence itself. The target is indicated at 27 and the intelligence to be transmitted in its revised form is taken therefrom.

It should be obvious from the foregoing that D. C. time modulation can also be achieved by modulating in the negative sense, i. e. by always reducing the duration of a comparatively long pulse; in practice, however, it is more economical to modulate in the positive sense.

In addition to the economy of power obtained by D. C. time modulation, the system has another advantage when utilised with any pulse modulating system having the time of occurrence of one or both edges of RL or RT pulses (hereinafter referred to as "solid pulses"), indicated by short pulses (said indicating pulses being hereinafter referred to as "marking pulses"), said other advantages being an increase in signal to noise ratio.

A characteristic of RL and RT pulses is that either the leading or the trailing edge of successive pulses occurs at equal time intervals, and consequently any short marking pulse derived from said leading or trailing edge must also occur at equal time intervals; these conditions being characteristic of D/RL, D/RT, RL+S/RL and RT+S/RT pulse systems. Use has previously been made of this equal time of recurrence characteristic in order to reduce the liability of random interfering signals impairing intelligence at

a receiver. It will be of advantage to review these previously known arrangements.

Referring to Fig. 1 of the drawings in the aforementioned Patent 2,256,336, and in particular to curve 15 of that figure, there is illustrated a D/RL pulse system. When utilising such a system at a receiver it is usual to make pulses marking the leading edges of corresponding solid pulses trigger a "double stability" circuit into the operative condition, and to make pulses marking the trailing edges of solid pulses trigger said double stability circuit into the inoperative condition. It is usual with time modulated pulse systems to utilise an amplitude filter at the receiver and to work as far as possible with the tips of the pulses. This expedient renders the receiver insensitive to all interference below the level determined by the amplitude filter. In cases of severe interference, however, it is possible for the double stability circuit to be triggered on or off at incorrect intervals, and in order to reduce the possibility of random interference it has been proposed, for instance with a D/RL pulse system in which the leading edge pulse occurs at equal time intervals, that, instead of triggering the double stability circuit into the operative condition directly by leading edge pulses, the double stability circuit is triggered on by a pulse derived from a leading edge pulse combined with the previous leading edge pulse which is fed over a delay network having a delay time equal to the interval between successive leading edge pulses.

The double stability circuit is triggered off by the variable trailing edge marking pulses, and cannot be triggered on again until the time of occurrence of the pulse derived from the combination of an undelayed and delayed leading fixed edge marking pulses, thus making the receiver unresponsive to any interference no matter how severe. This unresponsiveness may occur between the time of occurrence of the trailing edge of one pulse and the leading edge of the next succeeding pulse. If the unmodulated solid RL pulses from which the D/RL pulses are derived have a duration equal to the intervals between pulses, it can be seen from an analysis of the working of the above described system that 50% of all interference above the level decided by the amplitude filter cannot affect the receiver, while all interference below the level determined by the amplitude filter cannot in any case affect the receiver.

The time modulated pulse system described in pending patent application Serial No. 312,645 is similar to that described above, in that very severe interference can affect the receiver only during a limited period, when the "inserted pulses" are derived from a relaxation oscillator.

There have been previous proposals in which "inserted pulses" are derived from an oscillatory circuit, and in these cases also it is possible to limit the time when severe interference can affect the receiver.

The time during which very severe interference can affect the receiver can be considerably reduced by making use of D. C. time modulation, and in practice it is possible to make the liability to interference a function of the depth of modulation.

The manner in which this latter advantage can be achieved can be more readily understood by referring to Figs. 7 and 8 of the accompanying drawings.

Referring to Fig. 7 there is shown a train of D/RL pulses 41—48 derived from the pulses

(which for the remainder of this description are assumed to be RL pulses) shown in Fig. 6. The odd numbered pulses 41—47 mark leading edges occurring at fixed time intervals, while the even numbered pulses 42—48 indicate edges which may be varied in their time of occurrence. If under certain modulation conditions some of the pulses have their duration extended, as indicated by pulse 42a derived from an extended pulse 32, then the average duration of the pulses will be indicated by pulse 46a derived from an extended pulse 34. The odd numbered pulses are fed over a delay circuit which has a delay time equal to the interval between successive odd numbered pulses, and these delayed pulses are combined with the succeeding undelayed odd pulse, the derived pulse being utilised as previously described for triggering on a double stability circuit, which is triggered off by the even numbered pulses. Severe interference can only affect the receiver by triggering off the double stability circuit too soon, and it can be seen that under the modulation conditions shown, this possible time during which interference can affect the receiver is represented by the interval of time represented by the interval between the pulse 45 and 46a, expressed as a percentage of the interval of time between consecutive odd pulses. With lower percentage of time modulation, the time during which the receiver can be affected by severe interference remains small, while with high percentage of modulation this interference possible time extends to slightly greater than 50%.

Assuming that the unmodulated solid pulse has a duration equal to 10% of the time elapsing between the leading edges of successive pulses, and that under conditions of 100% modulation the pulse is extended to a duration of 95% of the time elapsing between the leading edges of successive pulses, then the average duration of a pulse will be 52.5% of said time, and the liability to severe interference will be the same percentage. With 30% time modulation, however, it can be shown that the liability to severe interference is reduced to 22.5% of the total time.

Referring to Fig. 8, there is shown on RL—S/RL pulse system which is D. C. time modulated in a manner similar to that described having reference to Figs. 6 and 7. The leading edges 49 can be utilised to synchronise a relaxation oscillator from which pulses equivalent to pulses 41 to 47 Fig. 7 can be derived, while the pulses 50 give the equivalents of pulses 42—48 Fig. 7. Owing to the fact that the relaxation oscillator cannot be triggered except when close to its normal triggering time, it disregards to a great extent severe interference, and therefore the pulses derived from said oscillator are largely independent of severe interference. This latter arrangement has therefore substantially all the advantages of the arrangement described having reference to Fig. 7. The solid portion of the pulse also economising in power as described having reference to Fig. 6.

D. C. time modulation can also be used with advantage in single pulse systems in which the marking pulses indicate the variable edges of solid pulses which have one edge occurring at equal time intervals. With such systems the missing pulse is derived from a synchronizing system, and it should be obvious that all the advantages claimed for the previously described arrangements also apply to single pulse systems.

It has previously been mentioned that with the circuit arrangements described that one effect of

severe random interference is to trigger off too early the double stability circuit at the receiver. This early triggering effect results in the particular pulse being made shorter in duration than it normally would be due to modulation. When interference becomes very severe and frequent in its occurrence, for instance, a frequency equal to about 10 times the frequency of the pulse frequency, the effect of such interference is to switch off a double stability circuit immediately after it has been switched on, giving an automatic muting effect to the receiver. This effect tends to apparently increase the signal to noise ratio in receivers.

It is to be understood that while we have described our invention in certain specific relationships and in connection with certain arrangements, given by way of example, we do not intend that the scope of the invention be limited thereto except as may be required by the claims which follow.

What is claimed is:

1. In an electrical signaling system, a source of time modulated pulse train representing signals of varying amplitudes, an electron beam tube having a cathode for emitting a beam of electrons, two sets of deflection plates for deflecting said

beam, a target in said tube upon which said beam impinges, a source of current of substantially constant frequency applied to one set of deflection plates, means for transmitting said pulse train to the second set of deflection plates, and means for varying said pulse train in accordance with the mean signal amplitude thereof.

2. In an electrical signaling system, a source of time modulated pulse train representing signals of varying amplitudes, an electron beam tube having a cathode for emitting a beam of electrons, two sets of deflection plates for deflecting said beam, a target in said tube upon which said beam impinges, a source of current of substantially constant frequency applied to one set of deflection plates, and means for transmitting said pulse train to the second set of deflection plates so that the periods defined by the pulses and corresponding to signal amplitudes have a mean duration which fluctuates in accordance with mean signal amplitude, said last means comprising a rectifier, a connection between said source of time modulated pulse train and the second set of deflection plates, and a branch path in said connection including said rectifier.

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