Oct. 28, 1947. P. K. CHATTERJEA ET AL 2,429,609

PULSE MODULATED TRANSMISSION SYSTEM

Filed July 12, 1943

FIG. 1.

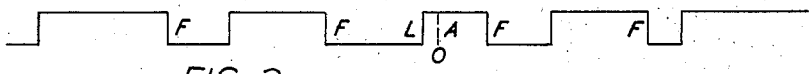


FIG. 2.

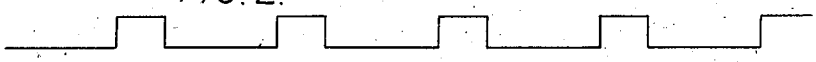


FIG. 3.

FIG. 4.

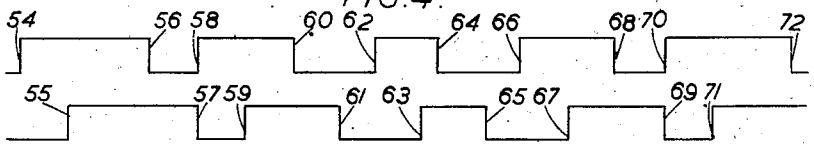


FIG. 5.

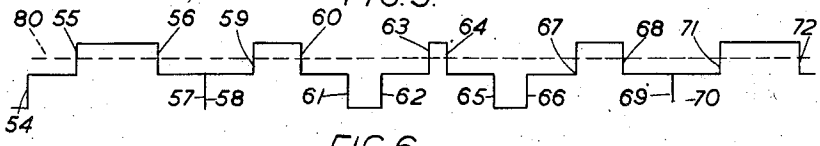


FIG. 6.

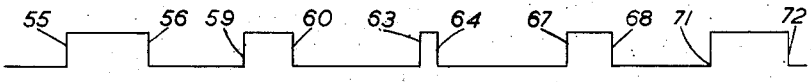


FIG. 7.

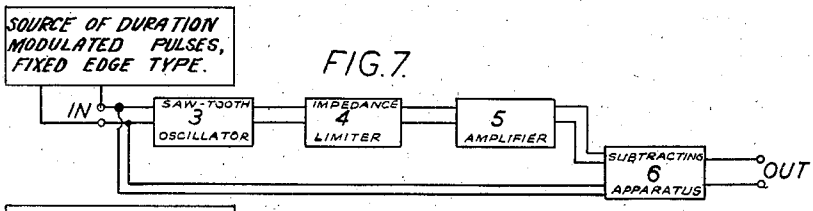


FIG. 8.

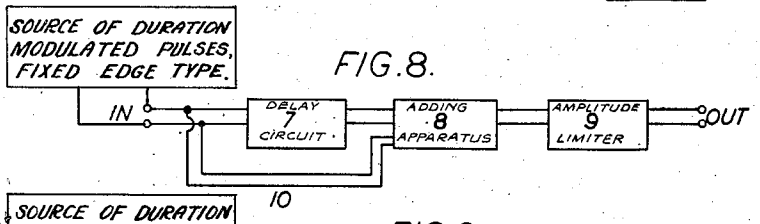
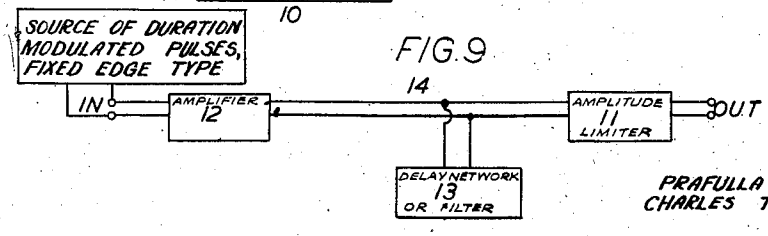


FIG. 9.



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PULSE MODULATED TRANSMISSION SYSTEM

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7 Claims. (Cl. 250—17.45)

1

The present invention relates to duration-modulated pulse transmitters.

Modulated-pulse transmission systems are now well known in which intelligence is transmitted by the variation or modulation of the durations of the successive pulses in a train of electrical pulses, in accordance with the variations in amplitude of the intelligence wave to be communicated. The pulses in such a train of pulses are said to be duration modulated.

If in such a pulse train, when conveying no signal, i. e. is unmodulated as regards the duration of the pulses, the duration of each pulse is equivalent to 50% of the pulse repetition period, and when modulated to the maximum depth of modulation is 85% for a positive modulation, that is an increase in pulse duration, and 15% for a negative modultion, that is a decrease in pulse duration, thus giving the shortest duration pulse, then the same intelligence could be transmitted by a pulse train in which the unmodulated pulses had a duration equal to 40% of the pulse repetition period. When this 40% pulse is modulated with the same limits of pulse duration variation the maximum and minimum pulse durations are then 75% and 5% of the pulse repetition period. From these considerations it will be observed that more power is required to transmit the same signal in the first case than in the second case. The signal does not depend upon the duration of the unmodulated pulse but only on the variations of the duration caused by the modulation. It will further be observed that in a pulse modulation transmitter of the type hereinbefore specified, when the pulse repetition frequency is fixed, the minimum pulse duration depends upon the maximum depth of modulation and that in cases where the maximum depth of modulation does not occur the pulses are of longer duration than need be with the consequent transmission of greater power than is necessary to convey the intelligence. It is an object of this invention to reduce the power transmitted required to convey any intelligence.

According to the invention means are provided in a duration-modulated pulse transmitter for shortening the duration of the pulses (or time-attenuating the pulses) before transmission so that the shortest pulse having the maximum depth of modulation is reduced to a desired minimum duration and all other pulses are shortened by correspondingly equal times.

The invention will be more clearly understood from the following description taken in conjunction with the accompanying drawings in which

2

Figures 1 to 6 are explanatory curves and Figures 7, 8 and 9 are block schematics of suitable circuit arrangements embodying the invention and given by way of example only.

Figure 1 indicates a train of duration-modulated pulses having one edge equally spaced in time, usually referred to as the fixed edge and indicated in the drawing by F. It will be assumed that the pulse A is the shortest pulse obtained by modulation with a particular signal wave. Such a pulse need not have such a long duration for transmitting the intelligence signal and all pulses may be and are, according to this invention reduced in time by the time represented by F0.

Figure 7 shows particular arrangements for obtaining this result. In this figure, any conventional (or any other) type of saw-tooth oscillator 3 is given the same frequency exactly, for example, by synchronisation, as the pulse repetition frequency of the pulse train as shown in Figure 1. This may be done, for example, in accordance with the principle utilized in the system of U. S. patent to Luck 2,113,214, issued April 5, 1938. In this system one train of impulses derived from the leading edges of the pulse train is used to initiate operation of one generator in synchronism with the pulses, and another train of impulses derived at the trailing edges of the pulses is used to operate another generator. The saw-tooth wave-form output from 3 is applied to an impedance limiter 4 of known type and then to an amplifier 5 so as to produce pulses of constant duration as shown in Figure 2. The duration of these pulses will be less than the duration of the shortest duration pulse A, Figure 1, and can be adjusted by adjusting the amplitude limiter device 4, Figure 7, as described for example in connection with Figure 1 of the specification of patent application No. 466,652/42 to produce pulses of the desired duration. The output pulses from the amplifier 5, or the pulses obtained in any other manner, are then subtracted in a suitable apparatus 6 from the pulses shown in Figure 1. For example, the pulses shown in Figure 2 may be reversed in sign and then added to the pulses shown in Figure 1, resulting at the output Out in the shortened pulses shown in Figure 3 but which nevertheless have the same modulation as the pulses shown in Figure 1. In Figure 7 the pulses shown in Figure 1 are fed at In to the oscillator 3 for synchronising this latter and to the apparatus 6 for combination with the output from amplifier 5 as described. The fixed edge of the pulses of Figure 1 will of course coincide with

the corresponding edge of the pulses shown in Figure 2. This may be attained in any known manner for example by adjusting the phase of the oscillator 3.

Two other arrangements for time-attenuating any type of pulse train are shown in Figures 8 and 9 in block schematic form.

In the arrangements shown in Figure 8, pulses such as 54—56; 58—60; 62—64; Figure 4 are fed at In to a delay circuit 7 having an appreciable delay and which may or may not be controllable. The pulses at the output of 7 will then be delayed with respect to the original pulses in the path 10, as shown by the pulses 55—57, 59—61, etc., Figure 4. The delayed and non-delayed pulses from apparatus 7 and path 10 are then combined in an additive manner in apparatus 8 to produce pulses of the kind shown in Figure 5. The output from 8 is then passed to an amplitude limiter 9 which only allows the portion of the pulses above the dotted line 30 to pass, resulting in the output Out in a pulse train shown in Figure 6, which is a time attenuated version of the pulse train shown in Figure 4.

In the arrangements represented in Figure 9 the pulse train, for example, as shown in upper curve Figure 4 is fed at In to an amplifier 12 and the output is fed to a transmission line 14 connecting with an amplitude limiter 11. At a point along the transmission line 14 is connected a delay network or filter 13 or other circuit device which will reflect the train of pulses back into the transmission line 14 so as to produce a delayed train such as shown in the lower curve of Figure 4. The direct and reflected trains will then appear together at the input of limiter 11 in the form shown in Figure 5 and the output of the limiter will be as shown in Figure 6, which is a time attenuated version of the original pulse train.

In Figures 7, 8 and 9 the rectangles represent known circuit arrangements which are considered not to require detailed description and represent any circuit arrangements fulfilling their required functions.

It will be observed that the time difference between the two trains of pulses to be combined in the arrangements shown in Figures 8 and 9 amounts to the duration by which the pulses in the original pulse train are to be shortened.

What is claimed is:

1. In a duration-modulated pulse transmitter, the combination including means to produce an initial train of duration-modulated pulses, means to produce a train of pulses having a predetermined form, frequency and phase relationship with said initial train of pulses, and means to combine the two said trains of pulses, said relationship being such that there is finally produced a train of pulses having the characteristic modulation of said initial train and in which each pulse has been modified in duration by a predetermined constant amount.

2. In a duration pulse modulation system in which each duration-modulated pulse has one edge accurately spaced in time from the corresponding edges of adjacent pulses, means to produce another train of pulses having corresponding edges spaced in time with the same accurate time spacing, means to adjust the time position of the other edge of each pulse of said last mentioned train of pulses, and means to combine said two trains of pulses algebraically to produce a resultant train of pulses.

3. In a duration-modulated pulse transmitter, the combination for shortening the duration of the pulses before transmission including means to produce an initial train of duration-modulated pulses, means to produce a train of constant duration pulses of opposite sign to the modulated pulses and having a duration equal to the time by which the durations of the modulated pulses are to be shortened and means to combine the two pulse trains so that the fixed edges of the modulated pulses coincide with the corresponding edges of the constant duration pulses.

4. In a duration-modulated pulse transmitter, the combination for attenuating the duration of the pulses before transmission including means for producing an initial train of duration-modulated pulses, means for producing from the train of modulated pulses a like train which is delayed in time, the delay amounting to the time by which the durations of the modulated pulses are to be attenuated, means for combining said initial and delayed trains in an additive manner, and amplitude limiting means for passing the peaks of the resulting pulses.

5. The combination as set forth in claim 4 in which said first and second named means include two parallel paths having a differential delay equal to the time by which the durations of the modulated pulses are to be attenuated.

6. In a duration-modulated pulse transmitter, the combination for shortening the duration of the pulses before transmission including means for producing an initial train of duration-modulated pulses, means for reflecting said train and for combining the initial and reflected trains with a time differential therebetween equal to the time by which the durations of the modulated pulses are to be shortened, and amplitude limiting means for passing the peaks of the resulting pulses.

7. The method of controlling the time duration of duration modulated pulses having one edge of each pulse accurately spaced in time from the corresponding edges of adjacent pulses, which comprises producing a train of pulses having the same accurate time spacing between corresponding edges, adjusting the time position of the other edges of said last mentioned train of pulses, and algebraically combining said last mentioned train of pulses with said modulated pulses to produce a resultant train of pulses.

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