April 1, 1947. D. I. LAWSON 2,418,268

PULSE MODULATION SIGNALLING SYSTEM

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FIG. 1.

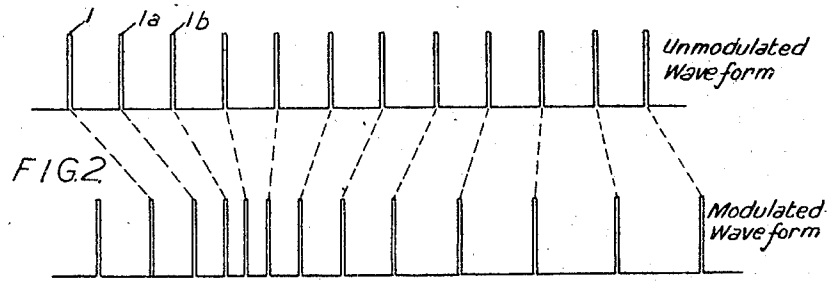


FIG. 2.

FIG. 3.

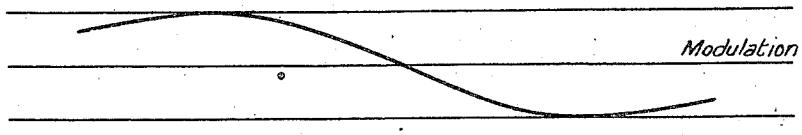


FIG. 4.

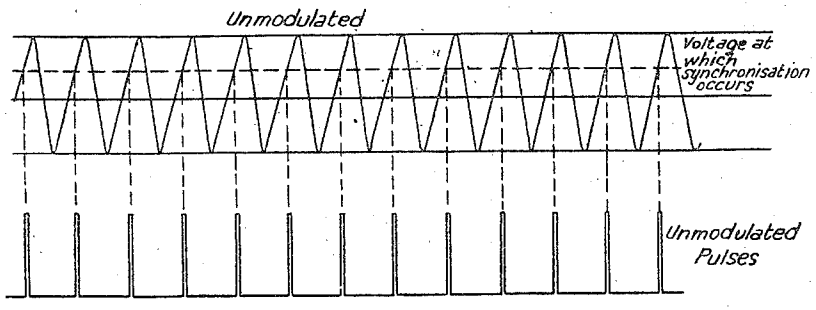
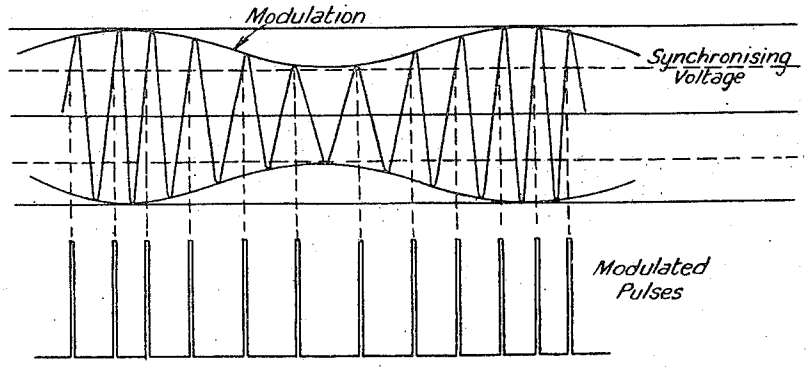


FIG. 5.



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FIG. 6.

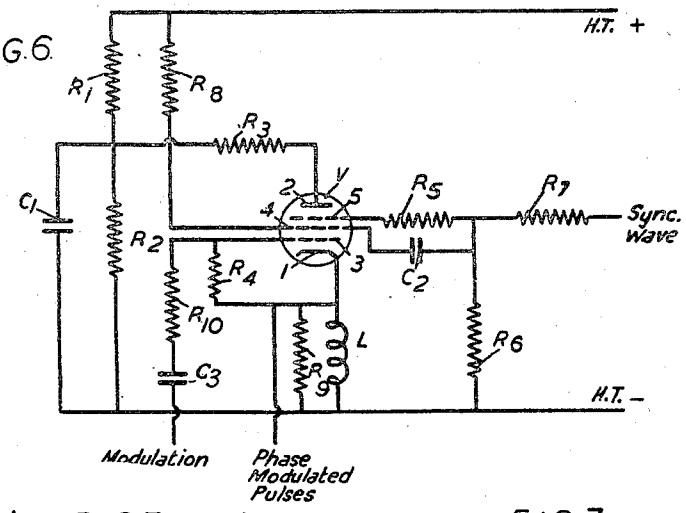


FIG. 7.

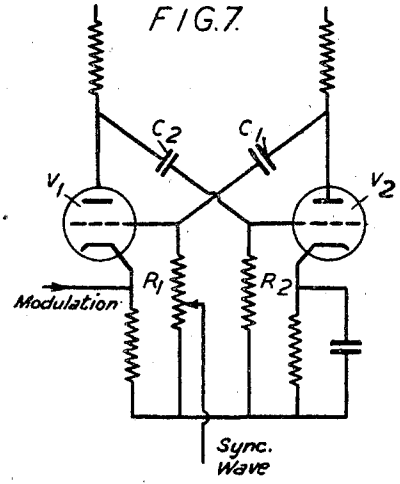


FIG. 7A.

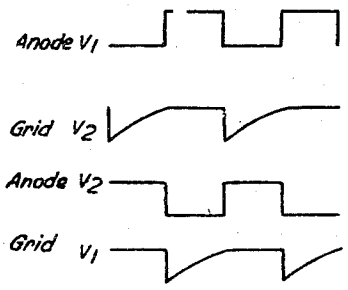
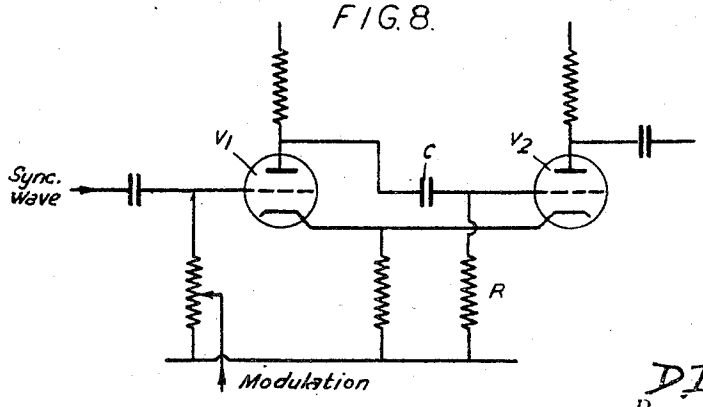


FIG. 8.



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UNITED STATES PATENT OFFICE

2,418,268

PULSE MODULATION SIGNALLING SYSTEM

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In Great Britain December 18, 1942

9 Claims. (Cl. 179—171.5)

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The present invention relates to a system of modulation for a signal transmission system in which the transmission takes place in a series of pulses, particularly for ultra-high frequency radio transmission employing, for example, centimetre waves. Hitherto the modulation of such signals has been effected by varying the pulse width.

It has also been proposed to modify the usual form of pulse width modulation by transmitting extremely short pulses to mark the beginning and end of each of the pulses of variable duration, which systems are known as double pulse systems. When the beginning of the variable width pulses takes place at equal intervals of time or when the end of the variable width pulses takes place at equal intervals of time, the short duration pulses corresponding to the beginning or end of the variable width pulses, whichever is equally spaced in time, (hereinafter called marker pulses,) may be eliminated at the transmitter and re-inserted again at the receiver. United States Patent No. 2,256,336 describes such systems and a method of generating the pulses of a double pulse system by means of a cathode ray tube, some of the embodiments generating only the short duration pulses corresponding to the end of the variable width pulse which varies in time. In all double pulse systems previously proposed, however, where the short duration fixed interval marker pulses are suppressed, it has been necessary to provide at the receiver for re-inserting the fixed interval marker pulses so that the waveform which is de-modulated corresponds to a variable width pulse waveform.

The present invention provides a system in which the intelligence is conveyed by a series of constant width pulses which are modulated in phase or frequency, the time interval between the pulses varying periodically in accordance with the frequency of the modulations to be transmitted. The amplitude of the modulation determines the amplitude of the phase displacement of the pulses. One advantage of this type of transmission is that the signals may be received and demodulated without having to insert any fixed interval marker pulses at the receiver, as was necessary in the prior systems above referred to.

A feature of the invention consists in an arrangement for generating frequency modulated pulses according to this invention which consists in triggering the pulse generators by means of

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a synchronising voltage upon which is superimposed the modulations. The synchronising wave may be amplitude modulated by the modulation, or, alternatively, the synchronising voltage and the modulations can be fed to the same or separate control grids of the triggering valve of the pulse generator. In either case the instant of triggering depends upon the instant at which the summation of the synchronising and modulation voltages reaches a sufficient voltage to trigger the pulse generator.

The invention will be more clearly understood by making reference to the accompanying drawings, in which

Fig. 1 shows the wave form of an unmodulated series of pulses.

Fig. 2 shows the wave form of the same series of pulses modulated in accordance with this invention.

Fig. 3 shows the modulation corresponding to the wave form of Fig. 2.

Fig. 4 shows one method of generating the series of pulses.

Fig. 5 shows the method of modulating t he pulses.

Fig. 6 shows the circuit of a transition oscillator modified for generating frequency modulated pulses in accordance with this invention.

Fig. 7 shows a circuit arrangement for carrying out the invention using a multi-vibrator.

Fig. 7A shows curves of the voltages appearing at the anodes and grids of the valves in the circuit shown in Fig. 7.

Fig. 8 shows a further circuit arrangement for carrying out the invention using a Kipp relay.

Fig. 1 shows a series of pulses 1, 1a, 1b etc., of constant width and constant spacing. The system of modulation according to this invention consists in shifting the phase of the pulses in accordance with the modulation.

Fig. 2 shows by way of example the pulses displaced in phase corresponding to the sinusoidal modulation voltage shown in Fig. 3. It will be seen that the time interval between successive condensations and rarefactions of the pulses is varied sinusoidally at the frequency of the modulation to be transmitted, whilst the amplitude of the modulation determines the amplitude of the phase displacement of the individual pulses.

The system of modulation according to this invention gives an improved signal to noise ratio compared with present amplitude modulated systems, since noise voltages along the horizontal

portions of the waveform may be limited, for example, by a diode, leaving noise only over the vertical regions of the waveform.

The method of producing the phase or frequency modulated pulses as above described will be explained with reference to Figs. 4 and 5. It is well-known that various types of relaxation oscillators, multi-vibrators, transitron oscillators and back coupled two stage amplifiers in which the valves alternately conduct, commonly designated as "flip-flop" circuits, may be made to generate pulses of short duration and that these pulses may be further sharpened by connecting a damped tuned circuit in the anode of the pulse generator. All these generators may readily be synchronised to any periodically varying voltage connected to a control grid. Thus, for example, if a sinusoidal voltage having a frequency of say 6 kc. is fed to a control grid of the oscillator, the repetition rate of the emerging pulses will be 6000 per second.

Fig. 4 illustrates in its upper part the sinusoidal synchronising voltage fed to the control grid, the lower part of the figure illustrating the unmodulated series of pulses which are initiated when the synchronising voltage reaches a predetermined value.

If now the synchronising wave is amplitude modulated, then the repetition frequency of the pulses will vary in a periodic manner as shown in Fig. 5 in accordance with the modulation frequency, the repetition rate of the pulses varying with the depth of the amplitude modulation and the synchronising level.

It is not necessary that the synchronising wave should be amplitude modulated; the synchronising voltage and the modulation could be fed to two separate control grids of a valve of the oscillation generator or even to the same control grid.

The signals transmitted will comprise a tone due to the synchronising frequency and the receiver should therefore be provided with means for eliminating this tone.

Figs. 6, 7 and 8 show circuit arrangements for producing the phase modulated pulses according to this invention. In Fig. 6 a circuit is shown which is generally known as a transitron oscillator and comprises the pentode valve V having a cathode 1, an anode 2 and three grids, namely, the control grid 3, the screening grid 4 and suppressor grid 5 arranged therebetween. The positive high tension is fed to the anode through the resistance R3 connected at the point of junction of the resistance R1 and R2 shunted across the high tension supply, the resistance R2 being shunted by a condenser C1. The screening grid potential is fed via the resistance R8, the screening grid also being connected through the condenser C2 to the junction point of the resistances R5, R6 connecting the suppressor grid 5 to the negative high tension lead. The control grid is connected to the cathode through the resistance R4.

The oscillations in the valve are maintained by virtue of the fact that the suppressor voltage-screen current characteristic curves of pentode valves exhibit negative resistance properties. The oscillator may be synchronised to any external voltage by applying this to either the suppressor or control grid electrodes. In Fig. 6 the sine wave synchronising voltage is applied to the suppressor grid 5 through the resistance R7 and the instant at which the valve is triggered is varied by applying the modulation to the control grid 3 of the valve through the condenser C3 and a resistance R10. The current in the anode circuit of the valve consists of a series of sharp pulses which are phase modulated. In the circuit shown these pulses are further sharpened by passing them through the heavily damped tuned circuit LR9 located in the cathode circuit of the valve.

Fig. 7 shows an alternative circuit arrangement for producing phase modulated pulses by means of a multi-vibrator. The multi-vibrator consists of a two stage resistance coupled amplifier, with feedback from the anode of valve V2 applied to the grid of valve V1. As the phase shift in each valve is 180°, the total phase shift for the two valves is 360°, i. e. the feedback is in the correct phase for the oscillation to be maintained. The operation of the circuit may be described as follows. Consider V1 initially in a non-conducting condition, then as soon as V1 conducts, the anode of V1 and hence the grid of V2 will fall in potential, and the valve V2 will become non-conducting, and will remain non-conducting until the charge has leaked away from the condenser C2 via the resistance R2 so that the grid potential of V2 can rise to a point at which the valve conducts. As soon as V2 conducts, the anode potential of V2 will fall sending the grid of V1 negative. The potential of the grid of V1 will rise as the charge leaks away from the condenser C1 via the resistance R1, and eventually V1 will again conduct. The waveforms at the various electrodes are shown in Fig. 7A. It will be seen that if a periodic voltage of a slightly higher frequency than the free running frequency of the multi-vibrator is applied to the control grid, the frequency of the multi-vibrator will be locked to the incoming frequency, for one cycle of the multi-vibrator will commence always when the voltage of the locking oscillation has risen to a given value. The locking oscillation may be applied in the control grid or the cathode circuit.

In the embodiment shown the synchronising voltage is applied to the grid and the modulation in the cathode circuit of the valve V1. Thus the instant at which V1 becomes conducting will depend on the modulation voltage applied i. e. the output pulse will be phase modulated. It will be seen that the modulation and synchronising voltages may be interchanged. Also other electrodes of multi-electrode valves could be used for applying the locking voltages.

Fig. 8 shows a further circuit arrangement comprising a Kipp relay circuit for generating the phase modulated pulses. The Kipp relay will not operate continuously without a locking pulse, as was the case with the multi-vibrator. Considering the cycle of events from the conditions where valve V1 is non-conducting and valve V2 is conducting. As soon as a positive input voltage is applied to the grid of V1, the valve V1 will conduct and the anode voltage of V1 will consequently fall. This will send the grid of valve V2 negative and V2 will cease to conduct. V2 will commence to conduct when its grid voltage which is rising at a rate determined by the values of the condensers C and resistance R is only slightly negative. As soon as V2 conducts the cathode voltage of V1 and V2 is increased, this decreases the anode current of V1 and the anode voltage of V1 rises. This is transferred to the grid of V2 via the condenser C and the current taken by V2 is further increased, the current in V1 falling by virtue of the increasing cathode voltage. In the end we are left with V2 conducting and V1 non-conducting as in the initial condition.

The instant at which the valve V1 commences to conduct will depend on the voltage between its grid and cathode. The oscillation may therefore be synchronised with any input applied to the grid of V1. The point at which synchronisation take place may be varied by applying the modulating voltage to the grid leak as shown. Obviously the modulation and synchronising voltages may be interchanged, or the voltages may be applied to other electrodes of multi-electrode valves.

I claim:

1. A transmitter for a communication system comprising a valve oscillator for generating a series of constant width pulses and means for controlling the oscillator by the modulation to be transmitted so as to vary the time interval between the pulses periodically in accordance with the frequency of the modulation.

2. Apparatus comprising a valve oscillator which generates a series of constant width pulses and means for triggering the oscillator and controlling the instants at which the pulses are produced by means of a periodic synchronising voltage upon which the modulation is superimposed.

3. Apparatus as claimed in claim 2, wherein the synchronising voltage is amplitude modulated by the modulation.

4. Apparatus as claimed in claim 2, wherein the pulse generator is triggered by the synchronising voltage and the modulation which are fed to the same means for triggering the pulse generator.

5. Apparatus as claimed in claim 2, wherein the pulse generator is triggered by the synchronising voltage and the modulation which are fed to separate means for triggering the pulse generator.

6. Apparatus comprising means for generating constant width current pulses and means for applying a synchronising voltage and a modulation voltage to the pulse generator so as to trigger the pulse generator at the instant at which the summation of the synchronising and modulation voltages reaches a predetermined value.

7. Apparatus comprising a valve circuit for generating pulses of short duration and constant width, the repetition frequency of which may be synchronised to a periodically varying voltage fed to one of the control electrodes of the valve, and means for feeding a synchronising voltage and a modulation voltage to at least one of the control electrodes of the valve to vary the frequency of the pulses in accordance with the modulation.

8. Apparatus comprising a transitron oscillator comprising a generator valve having an anode, a cathode and three control electrodes arranged therebetween, means for feeding a synchronising voltage to one of said control electrodes and a modulation voltage to another of said control electrodes to produce in the anode circuit of the valve a series of sharp constant width pulses which are modulated in frequency in accordance with the modulation.

9. A pulse modulation signalling system comprising a valve oscillator for generating a series of constant width pulses, means for applying modulation to the generator to generate the pulses at time intervals which vary periodically in accordance with the frequency of the modulation to be transmitted, means for transmitting the modulated series of pulses.

DENNIS ILLINGWORTH LAWSON.

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

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Disclaimer

2,418,268.—*Dennis I. Lawson*, Cambridge, England. PULSE MODULATION SIGNALLING SYSTEM. Patent dated Apr. 1, 1947. Disclaimer filed May 16, 1949, by the assignee, *Pye Limited*.

Hereby enters this disclaimer to claims 1 and 9 in said patent.

[*Official Gazette June 21, 1949.*]