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ELECTRICAL PULSE TIME MODULATION CIRCUIT

Filed March 2, 1946 2 Sheets-Sheet 1

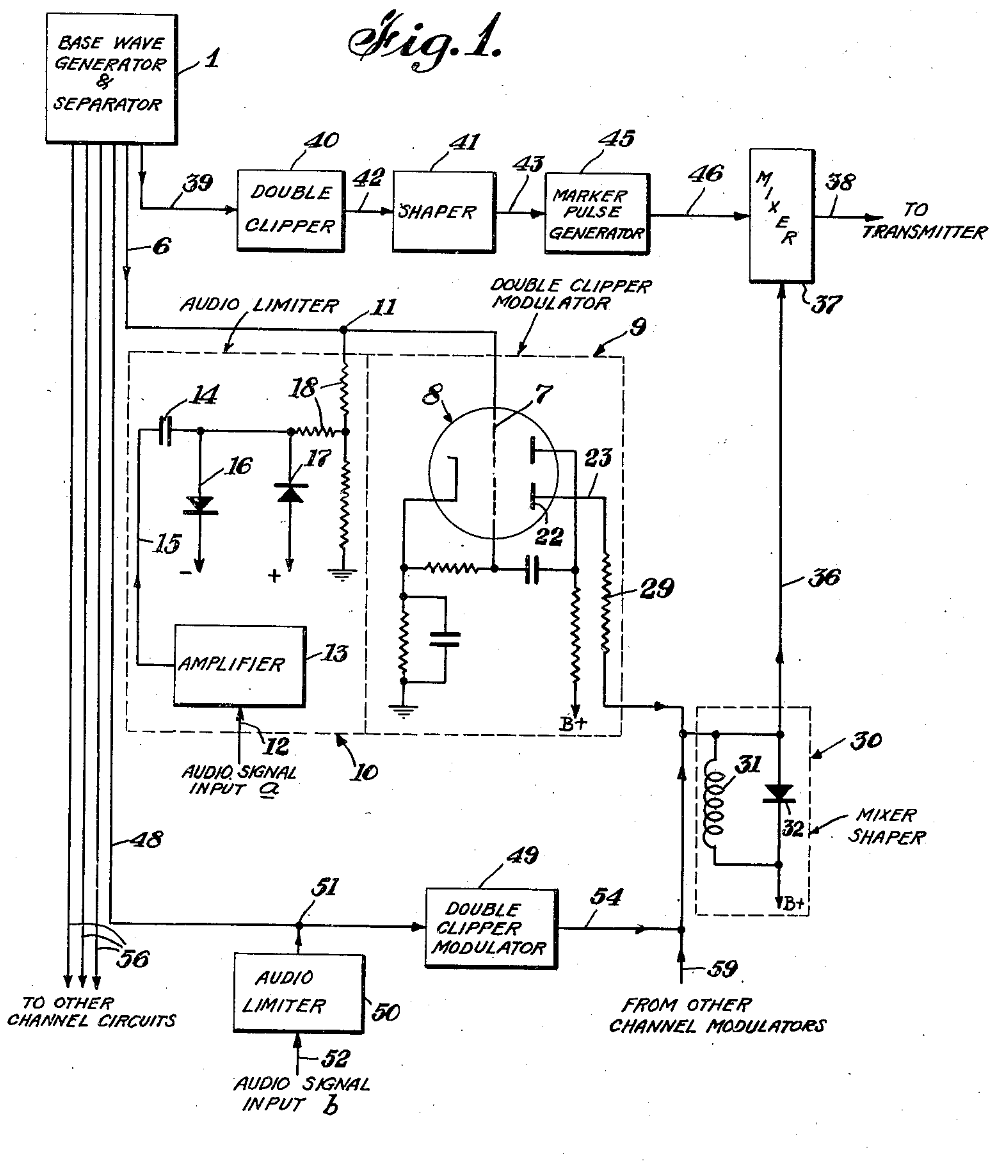

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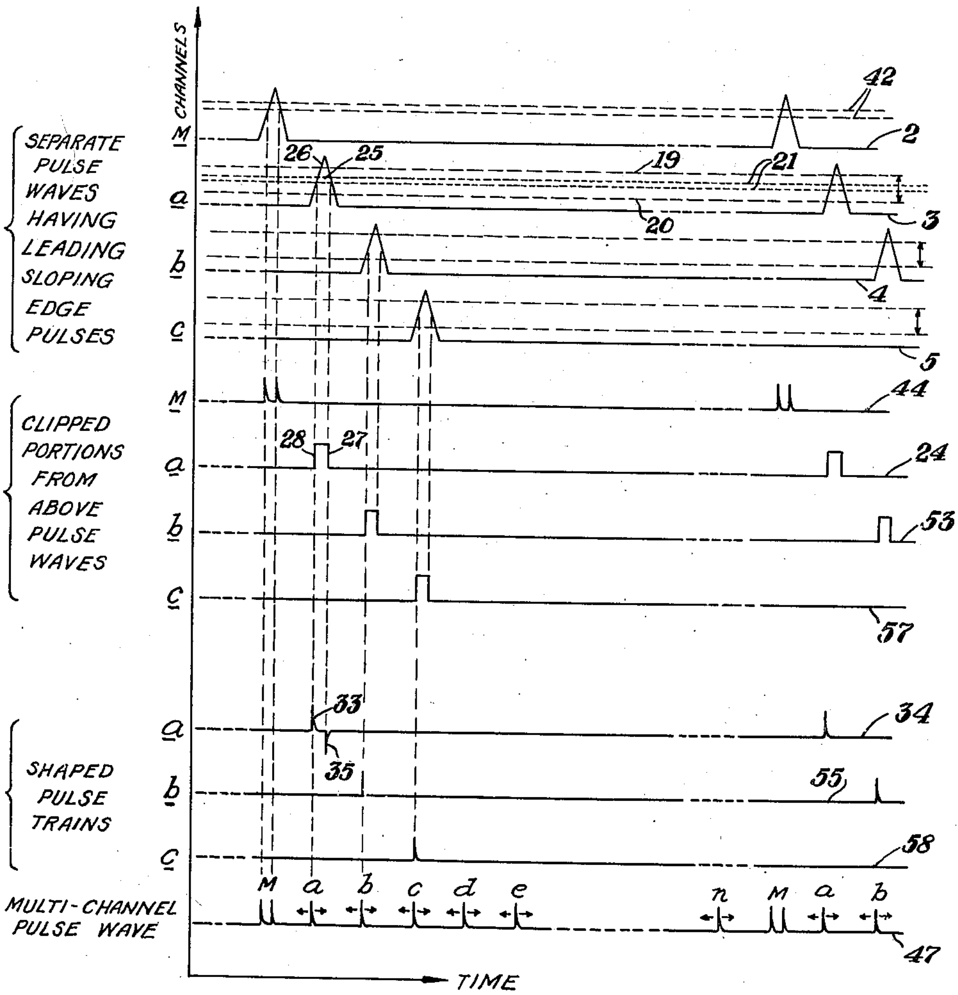
Fig. 2.



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ELECTRICAL PULSE TIME MODULATION CIRCUIT

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4 Claims. (Cl. 179—15)

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This invention relates to a pulse time modulation system. More particularly, it deals with a multichannel system for time modulating interleaved trains of pulses with respect to audio or other frequencies of intelligence.

An object of this invention is to time modulate pulses in a simple, novel and effective manner.

It is another object to provide a novel and effective multichannel pulse time modulation system.

It is another object to reduce cross-talk between the signals in different channels of a multichannel modulation system by limiting the signal input before it is modulated.

It is another object to provide a novel circuit for mixing the pulses of several channels on a single multichannel electromagnetic wave.

It is another object to provide a novel circuit for shaping the pulses in a pulse modulation system after the pulses have been modulated.

It is another object to provide a common circuit for mixing and shaping the modulated pulses of separate signal channels onto one multichannel pulse wave.

It is another object to provide a novel method of producing a steady marker or synchronizing pulse for a multichannel pulse time modulation system which marker pulse will not drift in time with respect to its regular repetition rate.

Other objects and features of this invention will appear from time to time in the description which follows:

Generally speaking, the pulse time modulation system of this invention comprises the following essential elements: (1) a base wave generator for producing a train of regularly recurring undulations, each of which undulations has a sloping, leading or trailing edge preferably of substantially constant slope; (2) a signal input circuit which may contain a limiter to limit the amplitude of the input signal; (3) a double clipper or gate modulator circuit in which the undulations on the base wave are clipped along their sloping edges at different amplitudes corresponding to the output from the signal input circuit; and (4) a pulse shaper circuit for producing time modulated pulses corresponding to the sloping edges of the portions clipped by the gate modulator from the base wave. If this system is employed for producing a multichannel pulse wave wherein a plurality of trains of pulses corresponding to different signal channels are interleaved on a single multichannel pulse wave, the essential elements should also include means for producing

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separate base waves for each signal channel, means for producing a marker or synchronizing pulse on the multichannel pulse wave so that the different channels may be separated therefrom at the receiver, and suitable means for mixing or interleaving the separate trains of pulses corresponding to each signal channel, as well as the train of marker pulses. This latter mixing means may be combined with the shaper element (4) for mixing the trains of time modulated pulses, and/or a separate mixer means may be provided for mixing the marker pulses with the time modulated pulses.

These and other features and objects of this invention will become more apparent upon consideration of the following detailed description of an embodiment of the invention to be read in connection with the accompanying drawings in which:

Fig. 1 is a schematic block wiring diagram of a preferred embodiment of the multichannel time modulation system of this invention; and

Fig. 2 is a graph of wave forms useful in explaining the operation of the system shown in Fig. 1.

Referring to the drawings, **1** is a base wave generator and a separator circuit from which may be withdrawn one or more base waves **2**, **3**, **4** and **5** (see Fig. 2), each of which contains a regular recurring undulation having a sloping edge, the leading edge, for example. In a multichannel system it is important that these waves be of the same frequency but be out of phase with respect to each other as shown in Fig. 2. Each one of the separate waves **2**, **3**, **4** and **5** is shown to be reserved for a different signal channel (as indicated in Fig. 2), namely, wave **2** is for the marker or synchronizing channel M, and waves **3**, **4**, **5**, etc., are for signal channels *a*, *b*, *c*, *d*, *e*, . . . *n*, respectively.

The circuit **1** may comprise a plurality of separate saw-tooth wave generators or shapers or each shaper may be connected to a single wave generator from which each of the separate channel waves are delayed different amounts so as to be out of phase with each other. This delay may be accomplished by a plurality of taps along a suitable delay line or by an electronic distributor means such as a "Cyclophon" described in the copending application of D. D. Grieg et al., Ser. No. 651,651, filed March 2, 1946. Although triangular shaped pulses are shown on the waves **2**, **3**, **4**, **5**, any shaped pulse which has a leading or trailing sloping edge, the slope of which is substantially constant on the recurring pulses, could be used as a base wave for the modulator of this invention.

For convenience, the modulator circuit for channel *a* will first be described in detail. Wave 3, corresponding to channel *a*, is withdrawn from the base wave generator 1 through line 6 and is passed onto the grid 7 of the double triode tube 8, in the double clipper and modulator circuit 9. The signal to be modulated is also applied to the grid 7 through the audio-input circuit 10 coupled to line 6 at the point 11. Signal channel *a*, which may be a code, audio facsimile, video, or the like, signal is introduced to the circuit 10 through line 12 and is preferably amplified in an amplifier circuit 13 before being passed onto the point 11.

The amount of modulation produced in circuit 9 may be limited by limiting the amplitude of the signal *a* before it is introduced into the circuit 9. This is particularly advantageous in the case of a multichannel pulse time modulation system wherein the higher amplitude signals often produce cross-talk between adjacent channels along the multichannel pulse waves. Thus, by limiting the amplitude of the input signal and thereby the amount of time modulation of each pulse, the amount of such cross-talk is materially reduced. The circuit for limiting this amplitude may comprise a coupling condenser 14 in the line 15 from the amplifier 13 and a pair of opposed rectifiers 16 and 17 in parallel with each other, one of which is biased negatively and the other of which is biased positively to the respective maximum amplitudes desired for the signal to be applied to the grid 7. These rectifiers 16 and 17 may comprise diodes, crystal rectifiers, or any other type of valve which will permit the flow of current in one direction only. Since these two rectifiers only pass the current in opposite directions, both the positive and the negative maximum amplitude of the signal in line 15 which is passed on through resistors 18 to point 11, will be determined by the highest negative and positive biases applied to rectifiers 16 and 17, respectively. For example, if these rectifiers were biased to +10 and −10 volts, and the input signal in line 15 had an amplitude of +15 and −15 volts, only +10 and −10 volts will be applied to the point 11, the remaining portions of the signal passing through the amplifiers 16 and 17. Similarly, if the signal in line 15 were less than ±10 volts, say ±8 volts, the entire signal would be applied to point 11 and thence to grid 7, without any decrease in amplitude since neither rectifier 16 nor 17 would become conductive because its applied bias would not be overcome. This limiter comprising the two oppositely biased rectifiers 16 and 17 in the signal input circuit 10, thereby limits the amplitude at which the double clipper or gate modulator 8 will clip sections from the undulations on the wave 3. This is graphically represented in Fig. 2 by the dotted lines 19 and 20 which indicate the upper and lower limits of the gate represented by the two dotted parallel lines 21 which clip segments at different amplitudes along each one of the pulses on wave 3.

The double clipper modulator circuit 9 is so coupled to the double triode 8 so as to produce the gate between the parallel lines 21 (in Fig. 2). This gate is moved up and down according to the signal applied from the circuit 10 to the grid 7. The details of the operation of such a double triode gate modulator are fully described in the copending application of E. Labin et al., Serial No. 455,898, filed August 24, 1942, now U. S. Patent No. 2,434,936. Thus, the output from plate 22 of gate modulator tube 8 in line 23 is similar to that shown on wave 24 in Fig. 2. The pulses on this wave 24, for example, correspond to the shaded clip section 25 from undulation 26 on wave 3 after it has been amplified to produce the pulse 27 on wave 24. The important part of this pulse 27 is the time position of its leading edge 28 which corresponds respectively to the portion along the sloping leading edge of the pulse 26 at which the gate 21 clips the pulse 26. The signals applied at point 11 from the circuit 10, therefore, moves the gate 21 up and down within the limits 19 and 20 according to the amplitude of the signal *a* introduced into circuit 10. The greater this amplitude the higher the gate 21 is along the edge of the pulses 26 and the more time delay there will be for the leading edge of the pulse 27 on the wave 24. Accordingly, the amplitude signal from the circuit 10 thereby is converted into a time modulated signal by the double clipper or gate modulator circuit 9 to produce the pulse wave 24. The wave 24 in line 23 may be passed through a resistor 29, inserted in the circuit for isolation purposes in the case of a multi-channel system, before it is introduced into the shaper circuit 30, which in a multi-channel system also may be a mixer.

The shaper circuit 30 comprises an inductance 31 and a rectifier 32 (which may be similar to the rectifier 16 or 17) coupled in parallel. The function of the inductance 31 is to differentiate the wide pulses 27 on wave 24 to produce the positive pulses 33 on wave 34 (in Fig. 2). This inductance 31 in the absence of the rectifier 32 would also differentiate the trailing edge of pulse 27 to produce the negative pulse 35, shown dotted on wave 34. However, the rectifier 32 is biased to a B+ voltage supply so that all negative undulations will be shunted out through the rectifier 32 thereby producing a wave of only positive pulses corresponding in time to the leading edges of the pulses on wave 24. This positive pulse wave may then be withdrawn from the circuit 30 through line 36 to any suitable utilization circuit, such as in a radio transmitter. In the case of a multi-channel system, line 36 may be coupled to a mixer 37 for mixing it with a marker pulse before it is passed on through line 38 to a transmitter. If the trailing edge rather than the leading edge of the base wave pulses are to be used, the input to shaper circuit 30 must be pulses of opposite polarity to those shown on the rectifier 32 must be reversed to pass only negative pulses to the common line circuit.

If it is desired, a marker pulse or synchronizing pulse may be produced from a separate channel base wave and stabilized in a circuit similar to that employed for channel *a* described above. Referring to the drawings, the wave 2 may be withdrawn wave generator 1 through line 39 into a double clipper circuit 40 similar to 9 except that a fixed bias is applied to the grid 7 through a suitable resistance coupled between the grid 7 input circuit and the ground. Otherwise, the circuit 9 would be identical to that used in circuit 40 and the fixed gate would clip the undulations on wave 2 between the clipping levels 42. Circuit 40 also may be followed by a shaper circuit 41 which may be identical with the circuit 30 described above for shaping the pulses. The output from the shaper 41 through line 43 would therefore be similar to the wave 44 shown in Fig. 2 except only the first of the pair of pulses would be present. The synchronizing or marker pulse wave then may be passed into a suitable marker pulse generator circuit 45 which may comprise the delay line for producing the double pulses as shown on wave 44, or may produce a wider pulse or any other shaped pulse which may be distinguished easily from the time modulated pulses on wave 34. A circuit for producing the double or pair of marker pulses shown on wave 44 is described in the copending case of D. D. Grieg, Serial No. 625,650, filed October 30, 1945, now U. S. Patent No. 2,485,591, issued October 25, 1949. Thus, from wave 44 withdrawn from generator 45 through line 46, may be passed into a suitable mixer 37, which may comprise a pair or more of triodes or other vacuum tubes the plates of which may be coupled together so that the waves 44 and 34 will be combined to a multichannel wave, such as wave 47 shown in Fig. 2 if only a marker pulse M and signal channel *a* pulses were shown thereon.

Similarly, other signal channels *b*, *c*, *d* . . . *n* may be modulated in circuits similar to circuits 9 and 10 by passing the wave 4 through line 48 into a suitable double clipper modulator 49 (similar to circuit 9) controlled by output of the limiter circuit 50 (similar to circuit 10) coupled through point 51 and into which signal *b* is applied through line 52. From the double clipper modulator 49 for signal *b* may be withdrawn wave 53 through line 54 which may be then passed to a shaper similar to shaper 30 or to the same shaper 30 coupled to the modulation circuit for signal channel *a* as is shown. Since the plates of all the modulator tubes 8 are connected together and to the circuit 30 and since the pulses produced in the separate modulator circuits are out of phase with each other, there will be no feedback from one modulator circuit into another. Therefore the outputs from a plurality of modulator circuits can be connected to the same shaper circuit 30 as shown.

Similary, other channel demodulator circuits may be coupled to lines 56 from the base wave generator and separator circuit 1 to other channel signal input or limiter circuits and other channel double clipper modulator circuits to produce waves 57, etc., and from it waves 58, etc., which are then passed through line 59 coupled to the input of the circuit 30. Thus, from circuit 30 in line 36 is withdrawn a wave similar to 47 shown in Fig. 2 without the marker pulses M. These marker pulses may be combined or interleaved with the time modulated pulses in the mixer 37 to produce the wave 47 as shown in Fig. 2. This multichannel pulse wave 47 may be passed through line 38 to any suitable utilization circuits such as a transmitter for transmission by radio or over a cable as desired.

While the above describes one specific embodiment by way of illustration, many variations in the details thereof may be had without departing from the scope of this invention. The specific description shown here is given by way of example, and is not intended as a limitation of our invention as set forth in the objects thereof and in the accompanying claims.

We claim:

1. A pulse time signal modulation system comprising: a signal source, a signal input circuit to limit the amplitude of the signal from said source; means for producing a train of pulses, each of said pulses having a sloping edge; a double clipper means for clipping the pulses at two levels along their sloping edges at various amplitudes determined by the output from said signal input circuit to produce variable width pulses and means for differentiating said variable width pulses to produce time modulated pulses corresponding to the sloping edges of said portions.

2. The system of claim 1, wherein the slope of the edges of all of said pulses is substantially the same.

3. A pulse time signal modulation system comprising: a signal source, a signal input circuit including two biased rectifiers to limit the peak amplitudes of the signal from said source to a given maximum level; means for producing a train of pulses, each of said pulses having a sloping edge; a double clipper means for clipping the pulses of said train at two levels along their sloping edges at various amplitudes determined by the output from said limited signal input circuit to produce variable width pulses having a maximum variation determined by said maximum level; and means for differentiating said variable width pulses to produce time modulated pulses from the sloping edges of said portions.

4. The system of claim 3, wherein said rectifiers are crystal rectifiers.

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