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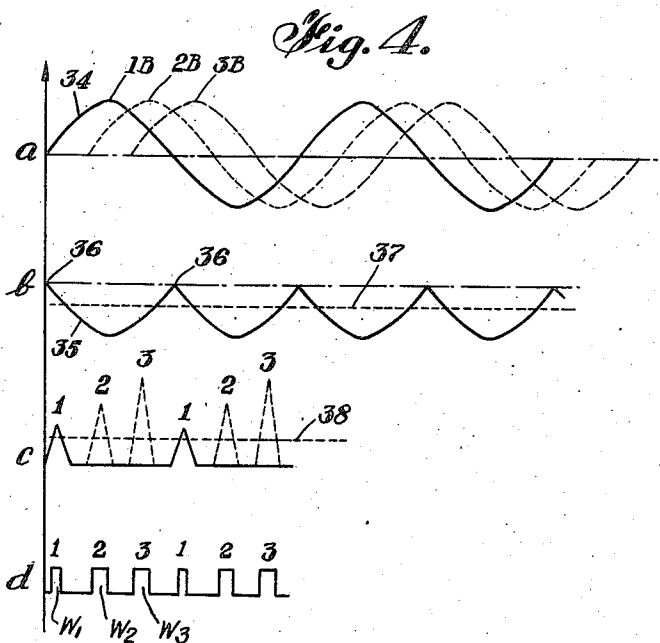
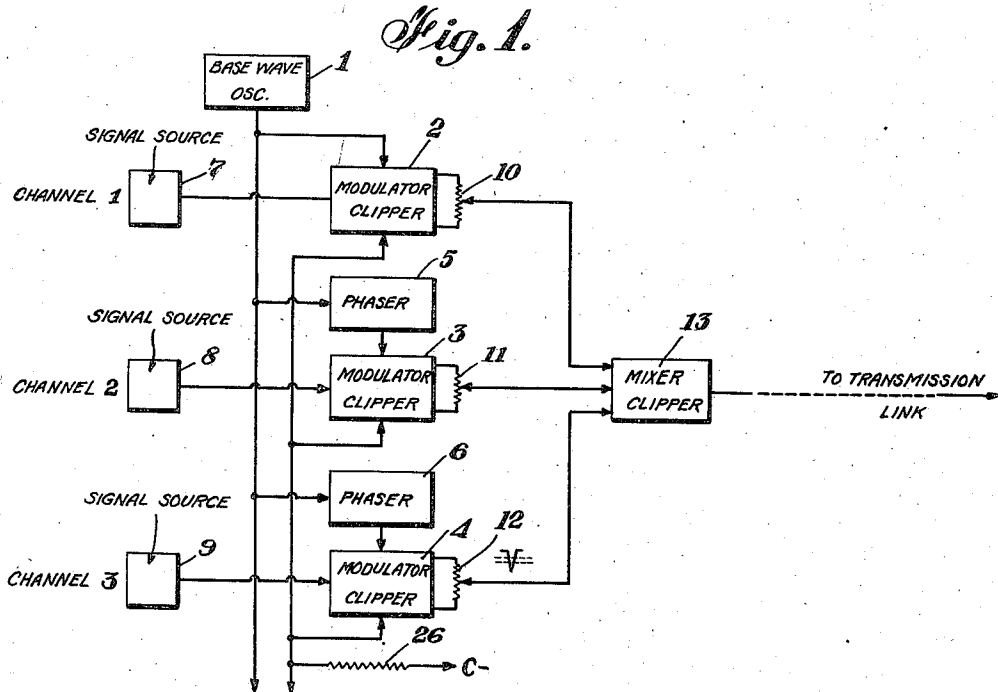
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PULSE WIDTH MODULATION MULTICHANNEL TRANSMITTING SYSTEM

Filed June 12, 1944

2 Sheets-Sheet 1



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Fig. 2.

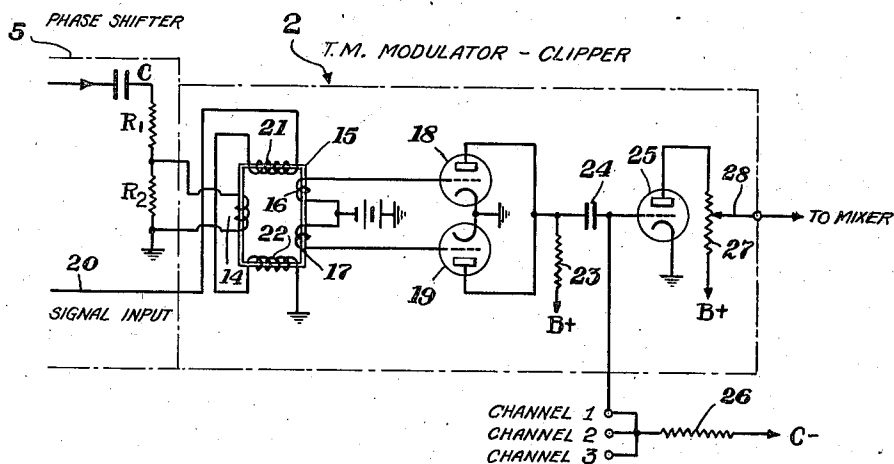
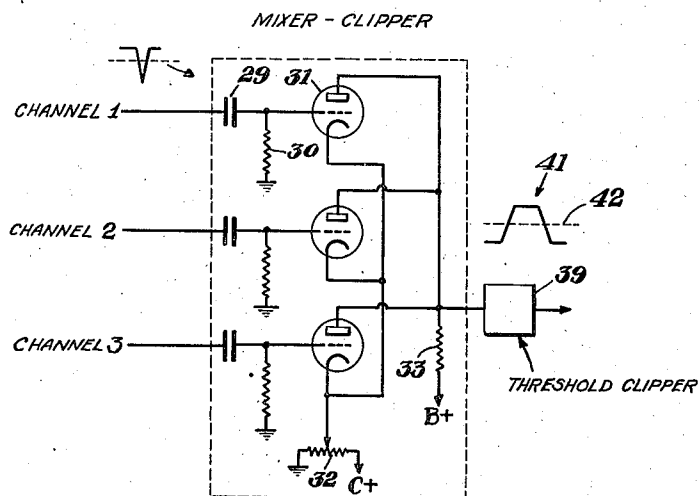


Fig. 3.



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PULSE WIDTH MODULATION MULTI-CHANNEL TRANSMITTING SYSTEM

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11 Claims. (Cl. 179-15)

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This invention relates to multi-channel pulse-type communication systems, and more particularly to multi-channel transmission systems and methods wherein the pulses of each channel differ from the pulses of other channels by a given pulse characteristic.

In the copending application, Serial No. 529,933 by E. Labin and D. D. Grieg, filed April 7, 1944, a multi-channel pulse communication system has been disclosed, wherein the pulses of the various channels are distinguished by various identifying pulse characteristics such, for example, as pulse width. The distinguishing pulse widths are obtained by means of pulse width shaper circuits which require separate biasing and different parameters for each channel.

One of the objects of this invention is to provide an improved method and means for transmitting over a multi-channel communication system.

Another object of the invention is to provide improved methods and means for multi-channel pulse type communication wherein the pulses of the various channels are distinguishable by their widths.

Another object is to provide in a multi-channel communication system of the type referred to, a transmitting terminal having substantially identical modulating equipment for each of the channels and a common mixer-clipping control for all channels.

In accordance with a feature of my invention, I provide a transmitting terminal for a pulse type communication system comprised of a plurality of channels, wherein each channel includes an identical pulse generator which is time modulated by a signal, and the output of which with respect to the amplitude of the pulses is made different for each channel in the output circuit thereof. The resulting channel pulse trains, being characterized by differences in amplitude, are then clipped at a common level, thereby resulting in pulses having a uniform amplitude but differing in width for the different channels.

The above and other objects and features of the invention will become more apparent upon consideration of the following detailed description to be read in connection with the accompanying drawings, in which:

Fig. 1 is a block diagram of a multi-channel transmitting terminal according to my invention;

Fig. 2 is a schematic representation of a circuit illustrating a phase shifter and a time modulator-clipper which may be used in any of the channels of the circuit of Fig. 1;

Fig. 3 is a circuit in schematic form of a mixer-clipper of the transmitter of Fig. 1; and

Fig. 4 is a graphical illustration of the operation of the transmitter of the invention.

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Referring to Fig. 1, a multi-channel transmitter is shown having a base wave oscillator or generator 1 which supplies a basic wave directly to a modulator-clipper 2, and a base wave which is delayed or shifted in phase to modulator-clippers 3 and 4 by means of the phasers or delay circuits 5 and 6. It will be of course understood that any additional number of channels as far as practicable, may be included in the transmitter. The modulator-clippers are seen to be supplied with modulating signals from signal sources 7, 8 and 9, respectively. The output of the modulators in each case is controlled by potentiometers 10, 11 and 12, which outputs are applied to a common mixer-clipper 13 feeding a transmission link, which may be either wire or radio frequency, as desired. The modulator-clippers are shown biased from a common source 26.

Fig. 2 shows the circuit of one form of a pulse time modulator-clipper such as may be employed at 2, 3 or 4 in Fig. 1, together with a phase shifter of the character used at 5 and 6. Phase shifter 5 comprises a condenser resistor network C-R₁, R₂, the relative values of which determine the phase shift for each channel of the base wave applied thereto from the base wave generator 1, Fig. 1. After being shifted in its phase, the base wave is applied to the modulator-clipper at a primary coil 14 of a coupling transformer 15. The modulator circuit includes two secondary coils 16 and 17 coupled to the control grids of two vacuum tubes 18 and 19 in push-pull arrangement similar to a full wave rectifier. Signal intelligence from signal sources 7, 8 or 9 is applied to the modulator by means of the input connection 20 to primary coils 21 and 22 on the transformer 15. The modulator is effective in producing a so-called cusper type wave which, for example, may be modulated in time by a signal, it is, of course understood that other forms of modulations, as for instance, with respect to pulse width may be recorded so. The cusper wave type output of the modulator is taken off a load resistor 23 and applied over a coupling condenser 24 to a clipper tube 25, the control grid of which is biased to a negative potential for clipping purposes by means of a bias source 26. This bias source 26 is common to all the clipper tubes in the modulator-clipper circuits of all of the channels. (See also Fig. 1.) The clipper tube 25 is supplied with a plate potential B+ through a resistor 27 which may also serve as an output amplitude varying potentiometer having an adjustable output terminal 28.

The output pulses clipped from the cusper wave of the modulator of each channel are preferably of negative polarity and are applied to the mixer-clipper circuit of Fig. 3 which, as shown, is adapted to accommodate three channels. The

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mixer clipper circuit comprises coupling elements 29 and 30 and a clipper tube 31 for each channel, which may be positively cathode-biased to cut off by means of a common bias source 32. It should be understood that the cutoff bias may also be obtained from a common (C-) source connected to the grids of the individual mixer tubes. The outputs of all of the clipper tubes 31 may be obtained across a plate resistor 33 serving as a common load resistor for all of the tubes 31. If desired, the pulses obtained across the resistor 33 may be further threshold clipped in the clipper 39.

The operation of the transmitter of Fig. 1 will now be explained with reference to Figs. 2, 3 and 4.

The base wave generator 1 is effective in producing a base wave of the type shown at 34 in graph *a* of Fig. 4. Three base waves 1B, 2B, 3B have been shown in graph *a* to indicate the relative phase position of the base waves as they are applied to the modulators 2, 3 and 4 respectively, either directly as in the case of channel 1, or by way of phase shifters 5 and 6 for channels 2 and 3. The rectifying effect of the modulator circuit of Fig. 2 results in a cusper type wave 35, shown in graph *b* of Fig. 4. This cusper wave is similar in all channels and has therefore been shown only with respect to channel 1. For the sake of clarity, the effect of the modulation in time on the cusper wave, or other forms of modulations by the signal has been omitted in this instance, as this effect is known in the art. It is pointed out that the linear portions of the cusps only are utilized during modulation and hence no change of waveshape occurs for this portion during the modulation process. If further linearity is desired the sine wave may be shaped into a triangular wave form before application to the modulator. For transmission purposes, the cusps, as at 36, are clipped from the cusper wave by the properly biased clipper tube 25 at a level 37 (graph *b*, Fig. 4) resulting in pulses identical for each channel of the general type shown in graph *c*. The amplitude of these pulses, which is originally the same for all channels, may be controlled for each channel by means of the potentiometer-load resistor 27, resulting in pulses having different characteristic amplitudes, as exemplified by pulses 1, 2 and 3 of graph *c*. The pulses of each channel, coming from their respective potentiometers 27, inverted in phase as at 40 (Fig. 3), are then clipped and amplified, all at the same level, by their respective mixer-clipper tube 31 (Fig. 3), which is biased from the common bias source 32, at the clipping level 38 (graph *c*, Fig. 4). Since each of the pulses before being applied to the mixer 13, has a different amplitude, their being clipped at the common level 38 will result in pulses having the same amplitude but different widths, characteristic for each channel, as shown in graph *d* of Fig. 4, wherein the different widths are indicated by W_1 , W_2 , and W_3 for the three channels respectively.

At 41, Fig. 3, a pulse as obtained from the mixer clipper tubes 31 is shown in detail, indicating its substantially trapezoidal form. Since the pulses thus produced differ from each other only in the top width of the trapezoid, having a similar width base, it may be desirable to further accentuate their width difference at either the transmission or the receiving terminal. If the former method is chosen, a possible solution is indicated in Fig. 3, wherein the pulses from the mixer-clippers 31

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are submitted to a threshold clipping operation at a common level in the clipper 39, the clipper 39 may be of the cathode-follower type, being productive of pulse portions as illustrated above the clipping level 42 of pulse 41. The pulses thus applied to a transmission medium (not shown) will now differ in width for each channel more nearly as in graph *d*. It is understood, of course, that this threshold clipping may, if convenient, be performed at the receiving terminal of the system.

It is thus apparent that the use of means for producing channel pulses having various widths as their distinguishing characteristic in the manner described, makes it possible for equipment to be used which is in part commonly controlled regardless of the number of channels employed, as well as making for desirable simplicity in the individual channel equipment.

While I have described above the principles of my invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation on the scope of my invention as set forth in the objects of my invention and the accompanying claims.

I claim:

1. A method of multi-channel communication comprising producing a series of pulses for all of a plurality of channels said pulses having at least one sloping edge, timing differently the pulses of the different channels, modulating the timing characteristic of the pulses of each channel according to instantaneous values of an intelligence signal, giving characteristic amplitude to the pulses of each of the channels, clipping the pulses of each channel thus characterized at a level common to all channels, thereby obtaining pulses of equal amplitude and different characteristic widths, and interleaving the different series of pulses together as a single train of pulses for transmission over a common transmitting medium.

2. A method of multi-channel communication comprising producing a separate series of pulses having a characteristic amplitude for each of a plurality of channels and of a type having a sloping edge, timing differently the pulses of the different channels, modulating a characteristic which is a function of the pulse timing of the pulses of each channel according to the values of an intelligence signal, clipping the pulses of each channel at a common level, and interleaving the different series of pulses together as a single train of pulses for transmission over a common transmitting medium.

3. A method of multi-channel communication comprising producing a separate series of cusper waves for each of a plurality of channels, timing differently said cusper waves of the different channels, clipping the said cusper waves at a common level to produce identical pulses for all channels, giving the pulses of each of the channels a characteristic amplitude, clipping the pulses of each channel thus characterized at a level common to all channels, thereby obtaining pulses of equal amplitude and different characteristic widths, and interleaving the different series of pulses together as a single train of pulses for transmission over a common transmitting medium.

4. A multi-channel communication system comprising separate means for producing a train of identical pulses for each of a plurality of chan-

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nels said pulses having at least one sloping edge having a control common to said channels, means for timing differently the pulses of the different channels, means for time modulating said pulses of each train in accordance with a signal, means in each channel for adjusting differently the amplitude of the pulses of the different channels, means for clipping said amplitude adjusted pulses at a level common to all channels, and means for interleaving the different trains of pulses together as a single train of pulses for transmission over a common transmission medium.

5. A multi-channel communication system comprising, in combination, generator means for supplying a base wave to each of a plurality of channels, means for timing differently the base wave for each of the channels, means for producing from said base wave in each channel a train of pulses identical for all channels, said pulses having at least one sloping edge, means for giving a characteristic amplitude to the pulses of each channel, means for clipping the pulses of each of said trains at a level common to all said channels, and means for interleaving the different trains of pulses together as a single train of pulses of different widths for transmission over a common transmission medium, said means for clipping including a clipper for each of the channels and a threshold clipper common to all said channels.

6. A multi-channel communication system comprising, in combination, generator means for supplying a base wave to each of a plurality of channels, means for timing differently the base wave for each of the channels, means for producing from said base wave in each channel a train of pulses identical for all channels, said pulses having at least one sloping edge, means for giving a characteristic amplitude to the pulses of each channel, means for clipping the pulses of each of said trains at a level common to all said channels, and means for interleaving the different trains of pulses together as a single train of pulses of different widths for transmission over a common transmission medium, said means for clipping including a clipper having a common bias adjusted to cut off for each of the channels and a threshold clipper of the cathode follower type common to all said channels.

7. A multi-channel communication system comprising, in combination, generator means for supplying a base wave to each of a plurality of channels, means for timing differently the base wave for each of the channels, means for producing from said base wave in each channel a train of pulses identical for all channels, said pulses having at least one sloping edge, means for giving a characteristic amplitude to the pulses of each channel, means for clipping the pulses of each of said trains at a level common to all said channels, and means for interleaving the different trains of pulses together as a single train of pulses of different widths for transmission over a common transmission medium, said means for giving a characteristic amplitude comprising a potentiometer.

8. A multi-channel communication system comprising, in combination, generator means for supplying a base wave to each of a plurality of channels, means for timing differently the base wave for each of the channels, means for producing from said base wave in each channel a train of pulses identical for all channels, said

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pulses having at least one sloping edge, means for giving a characteristic amplitude to the pulses of each channel, means for clipping the pulses of each of said trains at a level common to all said channels, and means for interleaving the different trains of pulses together as a single train of pulses of different widths for transmission over a common transmission medium, said means for producing identical pulses including a clipper tube for each channel and a common control grid bias for all said clipper tubes.

9. A multi-channel communication system comprising, in combination, generator means for supplying a base wave to each of a plurality of channels, means for timing differently the base wave for each of the channels, means for producing a cusper wave from said base wave in each channel, means for clipping the cusps of each of said channels, means for controlling said last-named means common to all channels, whereby identical pulses for all channels are obtained, means for giving a characteristic amplitude to the pulses of each channel, means for clipping the pulses of each of said trains at a level common to all said channels, and means for interleaving the different trains of pulses together as a single train of pulses of different widths for transmission over a common transmission medium.

10. A method of multi-channel communication comprising producing a separate series of pulses for each of a plurality of channels said pulses having at least one sloping edge, timing differently the pulses of the different channels, modulating a given characteristic of the pulses of each channel according to instantaneous values of an intelligence signal, giving the pulses of each of the channels a characteristic amplitude, clipping the pulses of each channel thus characterized at a level common to all channels, thereby obtaining pulses of equal amplitude and different characteristic widths, and interleaving the different series of pulses together as a single train of pulses for transmission over a common transmission medium.

11. A multi-channel communication system comprising separate means for producing a train of identical pulses for each of a plurality of channels said pulses having at least one sloping edge said means having a control common to said channels, means for timing differently the pulses of the different channels, means for modulating a given characteristic of said pulses of each train in accordance with a signal, means in each channel for adjusting differently the amplitude of the pulses of the different channels, means for clipping said amplitude adjusted pulses at a level common to all channels, and means for interleaving the different trains of pulses together as a single train of pulses for transmission over a common transmission medium.

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