

Dec. 24, 1946.

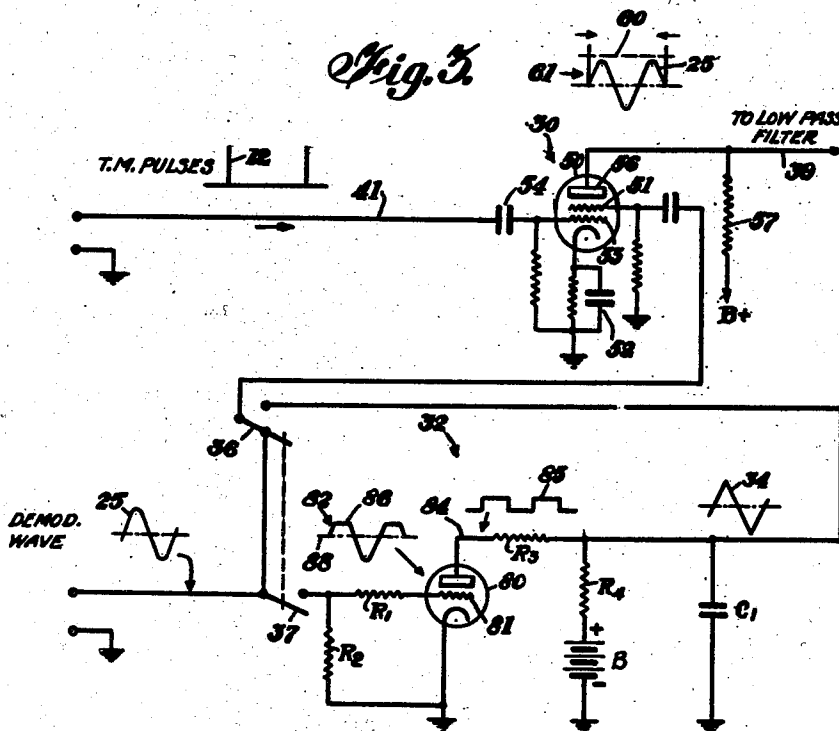
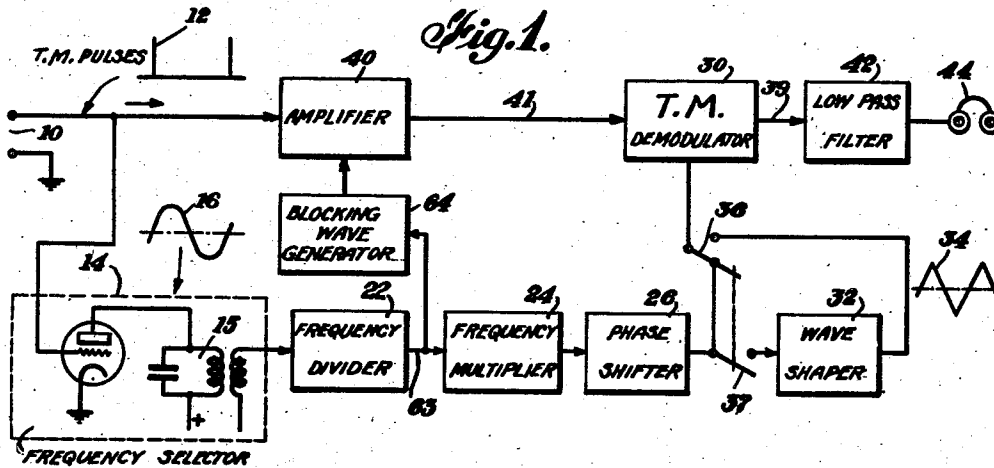
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2,413,023

DEMODULATOR

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2 Sheets-Sheet 1



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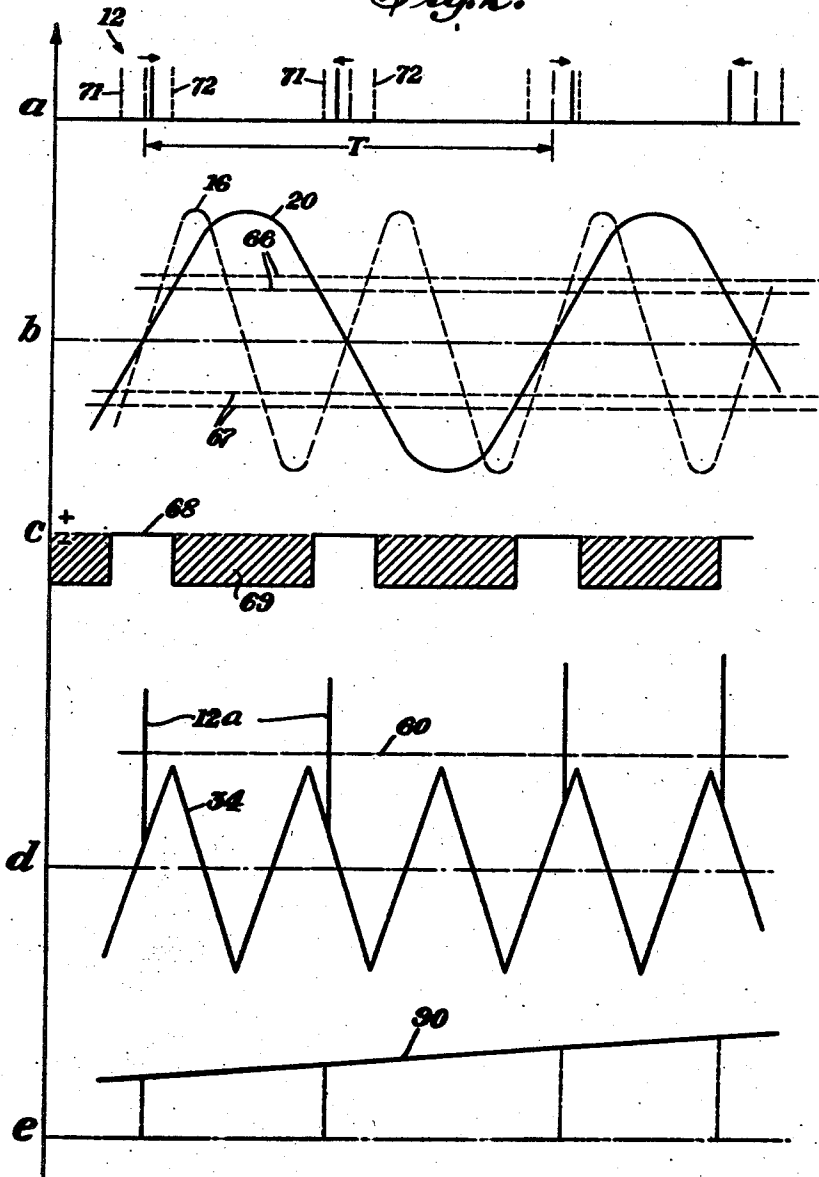
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Fig. 2.



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DEMODULATOR

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Application January 6, 1944, Serial No. 517,160

8 Claims. (Cl. 250-27)

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This invention relates to radio reception of TM (time modulated) pulse energy and more particularly to a system for demodulating or translating TM pulse energy into amplitude modulated pulse energy.

In my copending application, Serial No. 513,074, filed December 6, 1943, entitled "Modulators," I disclose a TM pulse modulation system wherein the pulses may be symmetrically or, in other words, uniformly timed with equal time intervals between successive pulses during the absence of modulation, the pulses when modulated being time displaced from their symmetrical positions in "push-pull" manner according to the instantaneous amplitude and polarity of the modulating signal energy. This form of TM modulation has the advantage over the form which provides an initial bias, that is, where the pulses are offset from the symmetrical time position during absence of modulation, in that the symmetrical timing permits greater interference blocking. TM pulses which are biased to an offset timing relation have two different sized time intervals alternating between the successive signal pulses, and only a blocking pulse corresponding to the smaller interval can be had without unduly complicating the receiving circuit. Further, in cases where very wide pulse displacements are desired, the wide displacements reduce further the size of the permissible blocking pulse thereby greatly reducing the advantageous effect obtainable by interference blocking.

It is one of the objects of my invention to provide an improved demodulating system for demodulation of time modulated pulses of the character symmetrically timed or biased to an offset timed relation, during absence of modulation, whichever is received.

Another object of the invention is to provide a demodulating and blocking system for pulses which are initially symmetrically timed, whereby substantially the entire time interval between the time displacement limits of successive pulses is blocked, thereby resulting in a higher signal-to-noise ratio than obtained by TM demodulators heretofore proposed.

A further object of the invention is to provide a demodulating or translation system capable of substantially linear translation of larger time displacements than possible by demodulators heretofore proposed.

The above and other objects ancillary thereto will become more apparent upon consideration of the following detailed description to be read in

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connection with the accompanying drawings, in which:

Fig. 1 is a schematic block diagram of a TM pulse demodulator according to my invention;

Fig. 2 is a graphical illustration used in explaining the operation of the demodulator; and

Fig. 3 is a schematic wiring diagram of wave translator and mixer units of the demodulator of Fig. 1.

Referring to Fig. 1, input terminals 10 are connected to the detector stage of the usual receiving circuit whereby TM pulses 12 of unidirectional polarity are provided. The TM pulses 12 are applied to a frequency selector 14 which serves to shock excite a high "Q" circuit 15 to produce a continuous wave 16 which preferably is an even harmonic of the fundamental wave used for producing pulses at a modulator such, for example, as the modulator disclosed in my aforesaid application. The wave 16, however, is preferably of a frequency which corresponds to the pulse repetition frequency.

While a shock excited circuit 15 is illustrated, it is clear that other forms of wave generators or selectors may be used. An oscillator operating at one half the repetition frequency of the received pulses may, for example, be used in the place of the shock excited circuit, the oscillator operating at a frequency which, in effect, averages the displacement timing of the pulses. For other examples of demodulating waves and wave producers for time demodulators, reference may be had to the co-pending application of D. D. Grieg, Serial No. 459,959, filed September 28, 1942.

In Fig. 2, where all curves have the same time base, curve *a* represents a short train of pulses time modulated according to a substantially linearly increasing signal wave. Curve *b* shows the wave 16 in timed relation to the pulses 12 and a fundamental wave 20 which is obtained from wave 16 by means of a frequency divider 22 which is inductively coupled to the circuit 15. The wave 20 is called a fundamental wave because it corresponds in frequency to the pulse period repetition rate of the "push-pull" time modulated pulses, the period being measured between alternate pulse positions as indicated at T on curve *a* of Fig. 2.

Either the initial wave 16 or the fundamental wave 20 may be used for demodulation purposes, but an odd harmonic of the fundamental wave 20 is preferred. Where wave 16 is to be used, curvature of the demodulator characteristic will be desirable. It is also desirable, where the de-

gree of TM is a small proportion of the period between pulses; that a high odd harmonic of the fundamental wave 20 be provided for demodulation in order to obtain an appreciable variation in amplitude for small changes in time displacement. The fundamental wave 20, therefore, is applied to a frequency multiplier 24, Fig. 1, whereby the desired odd harmonic wave 25, Fig. 3, or wave 34, Fig. 2, is obtained. While wave 25 is shown for purposes of illustration to be the third harmonic of the wave 20, a higher odd harmonic may be preferred in some cases.

A phase shifter 26 is provided in the output of the frequency multiplier to shift the demodulating wave in phase with respect to the TM pulses. The demodulating wave 25 may be applied directly to a demodulator 30 for translation of the time displacement of the pulses into amplitude modulated pulses, or it may first be reshaped, if desired, and then applied to the demodulator.

Where the time displacements are of relatively large magnitude, it is important that the translation be substantially linear, and to insure this result the sloping sides of the wave must be substantially linear throughout the possible displacement of the signal pulses. Therefore, in accordance with one of the features of this invention, I reshape the sine wave 25 to provide a wave form having long substantially linear portions such as the triangular wave 34. This wave reshaping is performed in a wave shaping circuit 32. Ganged switches 36 and 37 are provided whereby either the sine wave or the triangular wave may be used as the demodulating wave, one position of the ganged switches causing the wave energy 25 to by-pass the shaper 32 and the other position causing the wave energy to first traverse the wave shaper before application to the demodulator 30.

The TM pulses 12 are applied to the unit 30 through an amplifier 40. The intelligence signals conveyed by the TM pulses are obtained from the output 39 of the demodulator 30 through a low-pass filter 42 and reproducer 44.

Assuming that the sine wave 25 is used as the demodulating wave, switches 36 and 37 being in the positions indicated, the sine wave will be applied to the screen grid 51 of the vacuum tube 50. The tube is self-biased to cut-off by a resistance-capacitance circuit 52. The main grid 53 is connected through coupling condenser 54 to the outlet connection 41 of the amplifier 40, Fig. 1. The plate 56 is provided with a load resistor 57 from which connection 39 is applied to the low-pass filter 42.

The self-bias of the tube 50 is such that it will not respond to the input potential of the wave 25 but will respond to the energy of the TM pulses superimposed upon the wave 25. That is to say, the tube produces a pulse output in its plate circuit whenever the combined energy of wave 25 and pulses 12 exceed a given clipping level 60. Thus, pulses are produced at the output connection 39 which vary in amplitude according to the position of the TM pulses on the inclined portions of the wave 25. When the pulses are modulated toward each other as indicated by the arrows on the curve 61 of Fig. 3, the amplitude of the output pulses is increased. When the displacement modulation of the pulses is in directions away from each other the amplitude of the output pulses decreases.

For reduction of interference, a blocking wave generator 64 is supplied with wave energy from the output 63 of the frequency divider 22. The blocking wave generator is of any known type

and may include, for example, means for clipping the fundamental wave preferably in the manner of two spaced-apart gates as indicated by the clipping lines 66 and 67, curve b, Fig. 2. The output energies of the two gate clipping operations are suitably amplified and mixed to provide a blocking wave 68 as indicated by curve c, Fig. 2. It will be observed that the blocking wave is regular and blocks out substantially all of the intervals between the displacement limits of the TM pulses 12, the displacement limits being indicated by the broken lines 71, 72. This blocking wave is applied to the amplifier valve 40 in a known manner to control the bias thereof, whereby the negative portions 69 effectively block operation of the amplifier 40. Thus, all interfering pulses and voltage fluctuations occurring between the displacement limits of the TM pulses are eliminated and never reach the demodulator 30.

Should it be desired to reshape the sine wave to provide longer linear slopes, the wave will be fed through wave shaper 32 prior to application to the demodulator 30 by reversing the present positions of switches 36 and 37. The wave 25 is then fed to the grid 81 of a vacuum tube 80 over a resistor network R₁, R₂ whereby the sinusoidal wave 25 is translated into a substantially rectangular output wave 85 in the plate circuit 84. The wave form appearing on the grid 81 is indicated at 82 the tube operating between a saturation level 86 and a cut-off level 88. The flat portion 86 is caused by grid current flowing through the high resistance R₁. The rectangular output wave 85 is applied to a resistance-capacitance circuit R₃, R₄ and C₁. The plate circuit 84 is provided with current from battery B through the resistance R₃, R₄. The action of the high resistance R₃, R₄ in connection with the capacitance C₁, which is also fairly large, causes triangular wave 34 to appear across the capacitance C₁.

Assume, for example, that the triangular wave 34 of curved d, Fig. 2, is applied to the demodulator 30. It will be observed that the wave 25 has been translated into a triangular wave 34 the sides of which are substantially linear. Thus, regardless of the time displacement of the pulses along the sides of the wave 34, a substantially linear translation of the time displacement into amplitude modulation is effected. The TM pulses 12 of curve a are shown to be modulated in push-pull, as indicated by the arrows, according to a linearly increasing signal. This time modulation is shown to be translated into amplitude modulation by curves d and e, the pulse portions of pulses 12a (pulses 12 amplified) above the clipping level 60 representing the output of the demodulator 30. This amplitude modulated pulse output, as indicated at curve e, provides a signal wave 90 in the output of the low bias filter 42, the pulse portions defining the envelopes of the signal wave 90 being removed by the filter.

From the foregoing description, it is readily apparent that the circuit according to my invention provides a substantially linear translation of the time displacement of the pulses into amplitude even for very wide time displacements of the pulses. It is also clear that by using symmetrical pulse timing for the time modulated pulses according to my aforesaid copending application, the demodulator of the present invention provides for substantially complete blocking of the intervals between the time displacement limits of the pulses. It will be understood, however, that time modulated pulses of the off-set

type can also be linearly translated into amplitude modulation by the circuit of this invention.

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 my invention as set forth in the objects and the accompanying claims.

I claim:

1. A system for demodulating, the time displacement of pulses time modulated from a given timing relationship in accordance with substantially the instantaneous amplitude of an intelligence signal, comprising means responsive to the time modulated pulses to produce a first wave of a frequency corresponding to the average timing of said pulses, means to divide the frequency of said first wave to produce a second wave of which the first wave is an even harmonic, means to translate said second wave into a third wave the frequency of which is an odd harmonic of said second wave, and means for producing amplitude variations of said time modulated pulses proportional to the instantaneous values of said third wave at the instances of occurrence of said pulses.

2. A system according to claim 1 wherein the means for producing said third wave includes means for reshaping the wave into triangular form whereby the translation of large time displacements by means of the substantially linearly inclined sides of the triangular wave is made possible.

3. A system according to claim 1 wherein said given timing relation comprises a symmetrical timing of the pulses, and further, in combination with means to block substantially the entire interval between time displacement limits of successive pulses.

4. A system according to claim 1 in combination with means to produce blocking pulses from said second wave, said blocking pulses being timed to occur between said time modulated pulses, and means controlled by said blocking pulses to block said means for producing amplitude variations of said time modulated pulses, whereby interference occurring between the time displacement limits of the modulated pulses is substantially eliminated.

5. In a time modulated pulse communicating system in which the pulses are time displaced from a given symmetrical timing relationship in

accordance with the instantaneous amplitude of an intelligence signal, means for blocking interference energy occurring between successive pulses comprising means responsive to the modulated pulses to produce a first wave of a frequency corresponding to the average timing of said pulses, means to divide the frequency of said wave to produce a second wave of which the first wave is an even harmonic, means to produce blocking pulses from said second wave of a duration equal substantially to the intervals between the time displacement limits of successive time modulated pulses and timed to occur between said time displacement limits, valve means for said time modulated pulses, and means controlled by said blocking pulses to block operation of said valve means for the duration of said blocking pulses, whereby substantially the entire interval spacing between said time displacement limits is blocked.

6. A system for translating into amplitude modulated pulses, the time displacement of pulses time modulated from a given timing relationship in accordance with the instantaneous amplitude of an intelligence signal, comprising means responsive to the time modulated pulses to produce a demodulating wave of a frequency synchronized to the average timing of said pulses, means to reshape said demodulating wave into triangular form, valve means having a given threshold clipping level, means to feed the time modulated pulses to said valve means, and means to feed said triangular wave to said valve means, whereby the energy of said pulses combine with said triangular wave to exceed said threshold limit in amounts according to the amounts and direction of the time displacement of the pulses, the inclined sides of the triangular wave providing for substantially linear translation of the time displacement of said pulses.

7. A system according to claim 6 wherein the means for producing said demodulating wave includes means for translating the demodulating wave into an odd harmonic of the pulse period repetition frequency of said pulses.

8. A system according to claim 6 wherein said given timing relation comprises a symmetrical timing of the pulses, and further, in combination with means to block substantially the entire interval between time displacement limits of successive pulses.

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