

Sept. 5, 1944.

G. L. USSELMAN

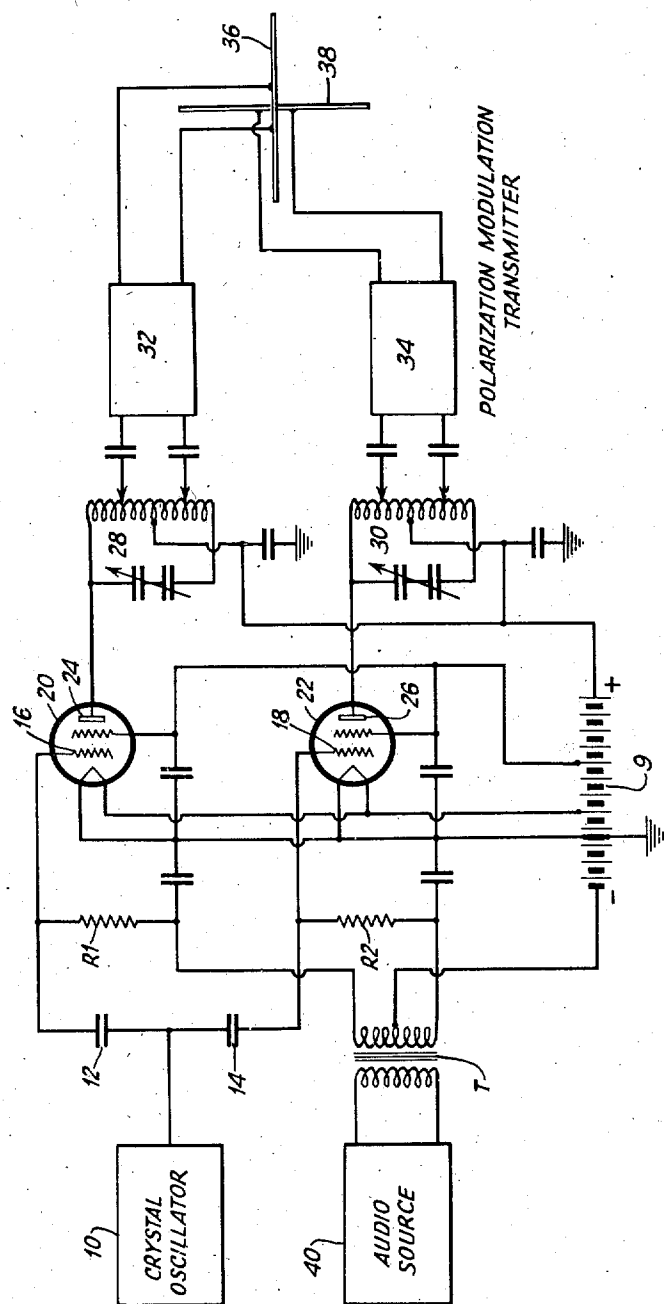
2,357,439

RADIO COMMUNICATION BY MEANS OF POLARIZATION MODULATION

Original Filed June 17, 1939

2 Sheets-Sheet 1

Fig. 1



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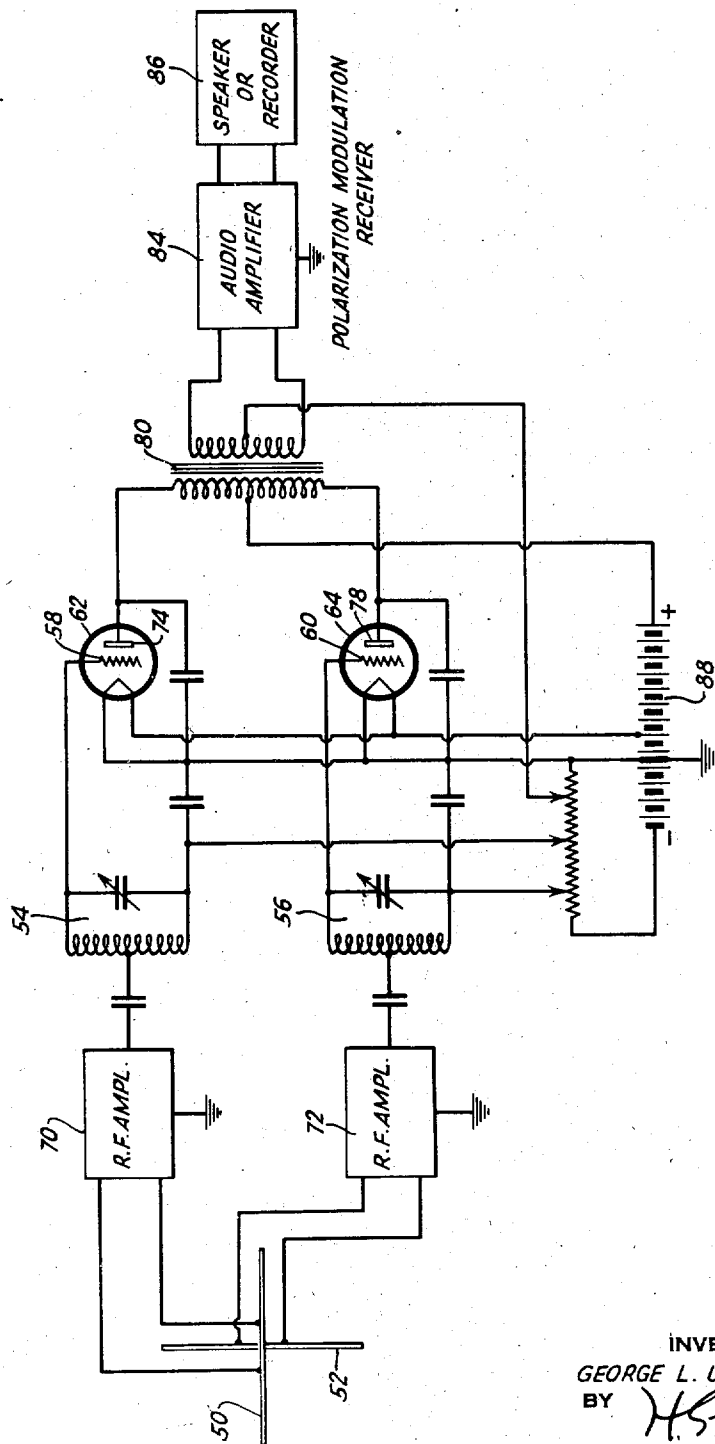
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Fig. 2



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RADIO COMMUNICATION BY MEANS OF POLARIZATION MODULATION

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Original application June 17, 1939, Serial No.
279,656, now Patent No. 2,273,911, dated Feb-
ruary 24, 1942. Divided and this application
June 12, 1941, Serial No. 397,700

7 Claims. (Cl. 250-6)

This application, which is a division of my United States application Serial No. 279,656, filed June 17, 1939, now Patent No. 2,273,911, granted February 24, 1942, concerns a new and improved method and means for radio communication, and, more particularly, a system of radio communication by means of polarization modulation.

It has been the practice in the prior art to transmit messages by means of amplitude, frequency or phase modulated signals, while the present invention uses polarization modulation as a means of signalling.

In describing my invention reference will be made to the attached drawings wherein Figures 1 and 2 together show an embodiment of my polarization modulation system.

In Fig. 1 and Fig. 2, I show a specific embodiment of one form of transmitter and receiver respectively, for radio communication by means of polarization modulated signals.

In the transmitter of Fig. 1 voltages characteristic of the wave to be modulated are supplied by source 10 to coupling condensers 12 and 14 and from condensers 12 and 14 in phase to the grids 16 and 18 of the two tubes 20 and 22. The anodes 24 and 26 of tubes 20 and 22 are connected to the tuned tank circuits 28 and 30 respectively. Tank circuits 28 and 30 are connected through amplifiers or frequency multipliers 32 and 34 respectively to antennas 36 and 38 respectively. The half-wave dipole antennas shown in Fig. 1 are for illustration purposes and they may be any suitable type. These antennas should be of a type to accentuate the polarization of the radiated waves. That is to say, the antennas 36 and 38 are of any suitable type, such as half-wave dipoles, which radiate waves polarized in different planes when the antennae are properly excited. For example, antenna 38 may radiate horizontally and antenna 36 may radiate vertically polarized waves. The antennas may be built in one unit or they may be built up in separate units.

It will be noted that antennas 36 and 38 in Fig. 1 are set in quadrature or 90° from each other so that the radiated waves have polarization angles differing by 90° though any angle may be used that proves to be most satisfactory for communication.

A source of modulating potentials 40 is coupled by a transformer T to the grid electrodes 16 and 18 of tubes 20 and 22 respectively.

In Fig. 2 I show a schematic circuit diagram of a receiver for reception of polarization modulated signals. 50 and 52 are the receiving antennas. These are shown as simple half-wave dipoles, though they may be of any suitable type of antenna and they may be built in one unit or they may be separated from each other. In Fig. 2 the antennas are set at 90° from each other but

they may be set at any suitable angle giving best results. These two antennas are connected by transmission lines to the grid tank circuits 54 and 56 respectively. The tuned circuit 54 is coupled to the grid 58 of tube 62 while the tuned circuit 56 is coupled to the grid 60 of tube 64. Radio-frequency amplifiers 70 and 72 may be used as shown to amplify the signals received by antennas 50 and 52 for the grid circuits 54 and 56. The anodes 74 and 78 of tubes 62 and 64 are connected in phase opposition to the push-pull transformer 80. The output of transformer 80 is connected through audio amplifier 84 to loudspeaker or recorder 86. The power source for the detector is shown as 88.

The principle of operation is as follows:

Radio-frequency excitation voltage is supplied in parallel or cophasally to the control grids 16 and 18 of tubes 20 and 24 from the oscillator 10 in Fig. 1. This carrier frequency is amplified or amplified and multiplied in tank circuits 28 and 30 and units 32 and 34 respectively, and then it is delivered to antennas 36 and 38 respectively. When there is no modulation present both antennas will radiate energy of equal intensity but this radiated energy will be polarized in different planes having a fixed polarization angle difference depending upon the position of antennas 36 and 38 and manner of excitation.

Now if audio-frequency signals are applied from source 40, they will be delivered in phase opposition through transformer T and resistors R1 and R2 to the control grids 16 and 18 of tubes 20 and 22. This signal then modulates the radio-frequency power to the antennas at an audio rate and since the audio modulation is in phase opposition, the radiation of one antenna will be a maximum when that of the other antenna is a minimum. The resultant radiated wave energy polarization will consequently swing back and forth through the radiation polarization angle of the antennas 36 and 38. Of course, this new system of radio communication may also be considered as operating over two paths of the same frequency. These two paths are oriented in space to have different polarization. The intelligence or signal is transmitted by differentially modulating the carrier energy of these two paths which have the unlike polarization.

The energy radiated from these transmitting antennas travels through space and some of it reaches the receiving antennas shown in Fig. 2. The polarization position or direction of the signal energy may change during its transmission through space but it will still retain its polarization oscillation or modulation. The energy picked up by receiving antennas 50 and 52, which are predominantly responsive to energy of a polarization corresponding to the polarization of the energy radiated by antennas 36 and 38

respectively, is transmitted through amplifiers 70 and 72 and tank circuits 54 and 56 to the grids of detector tubes 62 and 64 respectively. Tank circuits 54 and 56 are tuned to the signals received on antennas 50 and 52. The grid biases of tubes 62 and 64 should be set for maximum efficiency as detectors. Now as the polarization of the incoming wave energy varies, it will be detected by tubes 62 and 64 and translated into low frequency or signal frequency push-pull current and voltages by transformer 80. The audio-frequency signals from transformer 80 may be amplified by amplifier 84 and then transmitted to the loudspeaker or recorder 86.

Antennas 50 and 52 should be of a type which is sensitive to changes in polarization of the received wave energy so that when the polarization is such that a maximum amount of energy is intercepted by one antenna, a minimum amount of wave energy is intercepted by the other antenna. Then, as the polarization of the received wave energy oscillates back and forth through an angle corresponding to the rate and intensity of the audio-frequency modulating signals in the transmitter, the changes in polarization will be detected in the receiver by the push-pull detector and amplified into audible signals in the loudspeaker.

The receiver may also be considered as a means for detecting and amplifying the signal oscillations from the transmitter which radiates carrier energy over two paths of different polarization but of the same carrier frequency, the amplitudes of the two carriers being differentially modulated according to the signal oscillations.

These specific embodiments may be modified in a number of ways. In a modification I may use a screen grid, four element tubes in the various stages of the transmitter, and, particularly, in modulator stages of the transmitter.

I claim:

1. The method of receiving wave energy the polarization of which is modulated between two limits in accordance with variations between maximum and minimum of signalling potentials which includes the steps of, intercepting wave energy the amplitude of which is maximum when the polarization of said wave energy approaches one of said limits, intercepting wave energy the amplitude of which is maximum when the polarization of said radiated energy approaches the other of said limits, producing from each of said wave energies potentials varying in amplitude in accordance with the variations in amplitude of said intercepted wave energies and combining said varying amplitude potentials in an opposing relationship to reproduce the signal.
2. The method of receiving wave energies of like frequency and of unlike polarization and of amplitudes varying in accordance with signalling potentials which includes the steps of, intercepting one of said wave energies, intercepting the other of said wave energies, producing from each of said intercepted wave energies separate potentials of varying amplitudes and so combining said varying amplitude potentials as to reproduce the signal.
3. In apparatus for demodulating wave energy the polarization of which is modulated between limits at signal frequency, a first aerial predominantly responsive to wave energy of a polarity approaching one of said limits, a second aerial

predominantly responsive to wave energy of a polarization approaching the other of said limits, means coupled to each of said aerials for producing a potential varying in amplitude in accordance with the approach of the polarization of the intercepted wave energy to said limits, and means for combining said potentials in an opposing relationship to reproduce the signal.

4. In apparatus for demodulating wave energies of unlike polarization the amplitudes of which are modulated between limits at signal frequency, a first aerial predominantly responsive to wave energy of one of said unlike polarizations, a second aerial predominantly responsive to wave energy of the other of said unlike polarizations, a pair of electron discharge detector tubes having input electrodes and output electrodes, means coupling the input electrodes of one of said tubes to one of said aerials, means coupling the input electrodes of the other of said tubes to the other of said aerials, and means coupling the output electrodes of said two tubes in push-pull relation for opposing the outputs of said detector tubes.

5. In a signalling system, a first aerial adapted to radiate wave energy of a first polarization, a second aerial adapted to radiate wave energy of a second and different polarization, means for impressing wave energy of like frequency and phase on each of said aerials, means for differentially modulating said wave energies impressed on said aerials at signal frequency whereby wave energy of a polarity which varies at signal frequency is radiated, and means for receiving and demodulating the radiated wave energy comprising a first aerial predominantly responsive to wave energy of said first polarization, a second aerial predominantly responsive to wave energy of said second polarization, a pair of electron discharge detector tubes each having input electrodes and output electrodes, means coupling the input electrodes of one of said tubes to one of said aerials, means coupling the input electrodes of the other of said tubes to the other of said aerials, and means coupling the output electrodes of said two tubes in push-pull relation for opposing the outputs of said detecting tubes.

6. In a signalling system, an aerial adapted to radiate wave energy of a first polarization, a second aerial adapted to radiate wave energy of a second and different polarization, means for impressing wave energy of like frequency and phase on each of said aerials, means for differentially modulating the amplitudes of said wave energies impressed on said aerials whereby wave energies of unlike polarization are radiated, means for receiving and demodulating the radiated wave energies, and means for opposing the outputs of said demodulating means.

7. The method of radio signalling which comprises producing a pair of radio frequency waves polarized at different angles and simultaneously modulating in accordance with the signal the amplitude of said waves in opposite senses whereby the plane of polarization of the resultant wave is varied in accordance with said signal, intercepting said waves, detecting the modulation on said waves and combining the detected modulations in opposing senses to reproduce the signal.

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