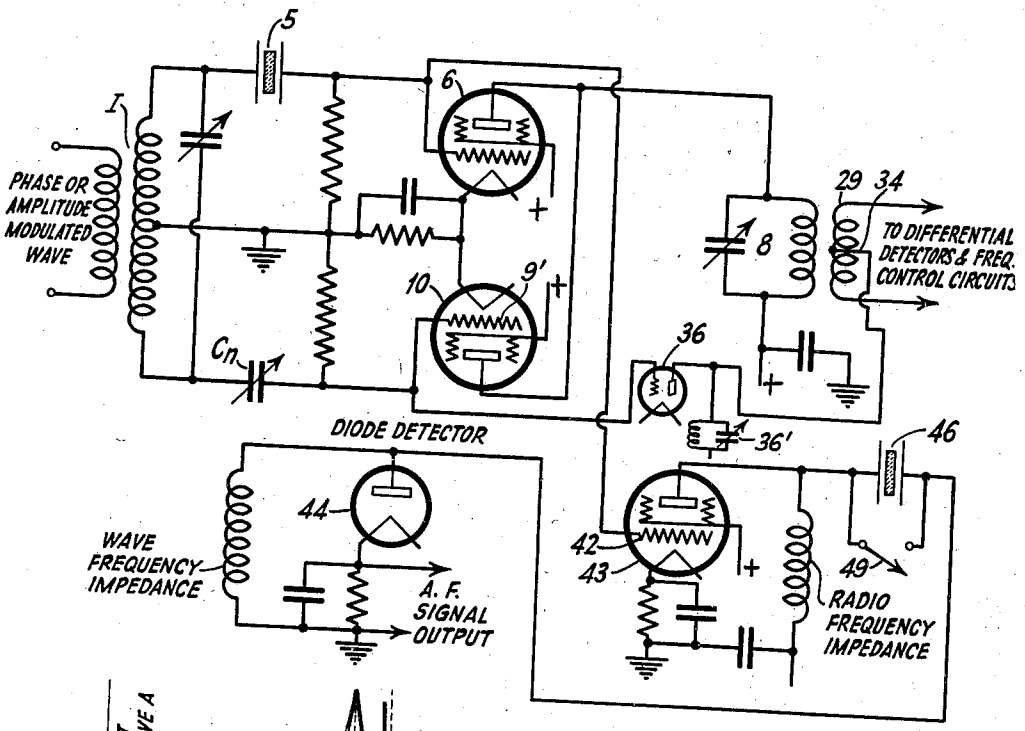
May 16, 1939. M. G. CROSBY 2,158,276

RECEIVER FOR AMPLITUDE OR PHASE MODULATED WAVES

Original Filed Nov. 2, 1935

Fig. 1



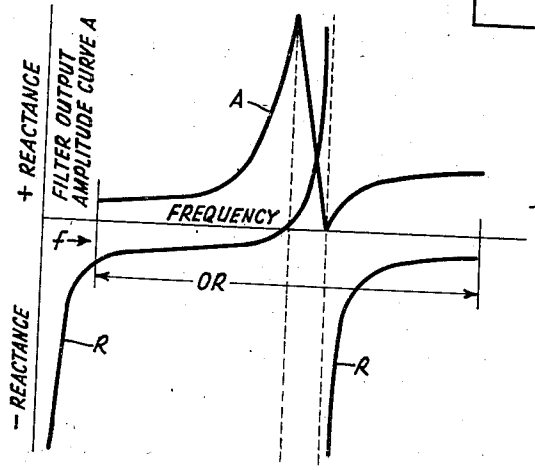


Fig. 2

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RECEIVER FOR AMPLITUDE OR PHASE MODULATED WAVES

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Original application November 2, 1935, Serial No. 47,933, now Patent No. 2,085,008, dated June 29, 1937. Divided and this application April 21, 1937, Serial No. 138,116

8 Claims. (Cl. 250—20)

This application is a division of my copending application Serial No. 47,933, filed November 2, 1935 and granted June 29, 1937 as Patent #2,085,008. Figure 1 of this case corresponds to Figure 7 of my said copending parent patent.

The principal object of my present invention is to provide an improved amplitude modulation receiver. In carrying this object into effect, amplitude modulated waves are changed into phase modulated waves and the phase modulated waves are then used to reproduce the transmitted signal.

Other features and objects of my invention will appear as the more detailed description thereof proceeds.

Figure 1 of the accompanying drawing is a schematic wiring diagram of my improved amplitude modulation receiver, which receiver is also provided with means enabling it to receive and detect transmitted phase modulated waves.

Figure 2 is a curve of the amplitude versus frequency characteristic of the unneutralized crystal filter circuit.

The circuit of the drawing shows an arrangement whereby the principles of this disclosure may be applied to the reception of amplitude modulation accompanied with carrier wave exaltation. The first crystal **5**, as to its unneutralized output, converts the incoming amplitude modulation to phase modulation by shifting the sidebands relative to the carrier in the same direction, as explained more fully in my parent patent, and also introduces some carrier exaltation of sideband depression. This converted filtered energy is then passed from the output of crystal **5** to the control grid **42** of coupling tube **43** and thence to a second crystal filter **46**. This second crystal filter converts the phase modulated energy received from the first crystal filter back into amplitude modulated energy, by shifting both sidebands ninety degrees in the same direction, so that amplitude modulation detection may be accomplished. A further carrier exaltation is also effected in this second crystal filter **46**. Tube **44** is a diode detector coupled to **46** to detect the amplitude modulation. The neutralized filter energy, as explained in my copending patent, is taken from the common plate circuit **8** of tubes **6** and **10** and fed to automatic frequency control detectors, not shown, in the same manner as in the circuit of Figure 9 of my copending parent patent. Unfiltered energy may be fed from circuit **1** by way of a coupling tube in **36** to a point **34** on the winding **29** coupled with **8**. Phasing of the unfiltered energy may be accomplished at **36'**. The frequency control circuit may be as in Figure 9 of my copending patent.

Switch **49** in Figure 1 provides a means for shorting out the second crystal **46** to convert the receiver back to a phase modulation receiver.

When only a single crystal filter is used, as for phase modulation reception, amplitude modulation comes through to a certain extent due to the single sideband action of the crystal filter. Since the sidebands on one side of the carrier are eliminated due to the dip point in the unneutralized filter characteristic, the filter acts as a single sideband filter for the lower modulation frequencies. Thus, the lower modulation frequencies of either phase or amplitude modulation will come through on the phase modulation adjustment.

The principles utilized in this disclosure are not limited to the use of crystal filters. Thus, any mechanical filter or artificial line type of circuit may be used. The fundamental requisite is that the phase be shifted either capacitive on both sides of the resonant frequency or inductive on both sides of the resonant frequency. The required effect is the shift of the carrier in phase with respect to the sidebands or vice versa. The fundamental circuit of Figure 5 of my parent patent has other "equivalent" circuits which will perform the same function.

As explained more fully in my copending patent, the amplitude versus frequency characteristic of the unneutralized crystal filter circuit is shown by curve A of Figure 2. The reactance of the unneutralized crystal filter circuit is given by the curve R of Figure 2. Thus, it should be apparent that the reactance of the unneutralized crystal filter over the operating range OR is predominantly reactive in the same sense on both sides of the resonant mean operating frequency.

Having thus described my invention, what I claim is:

1. In a demodulating system, a plurality of filter circuits each having an input and an output, the characteristic of each of said filter circuits being predominantly reactive in the same sense on both sides of the frequency to which the filter circuit is resonant, means for applying an amplitude modulated wave to the input of one of said filter circuits, means connecting the output of said one filter circuit to the input of the other filter circuit, and a utilization circuit connected to the output of said last filter circuit.

2. An amplitude modulation receiver comprising a circuit for receiving amplitude modulated waves, a second circuit coupled to said first men-

tioned circuit for transforming said amplitude modulated waves into phase modulated waves, and means for deriving the transmitted signal from said phase modulated waves.

3. The method of demodulating amplitude modulated waves which includes the steps of, transforming the amplitude modulated waves into phase modulated waves and then transforming the phase modulated waves into the transmitted signal.

4. The method of signaling which includes transforming amplitude modulated waves into phase modulated waves, then transforming the phase modulated waves into amplitude modulated waves, and then detecting and translating the amplitude modulated waves.

5. A receiving system comprising means for receiving amplitude modulated waves, a circuit for transforming the received waves into phase modulated waves, an amplifier for amplifying the phase modulated waves, a second circuit connected to said amplifier transforming said phase modulated waves into amplitude modulated waves, and a detector for detecting said amplitude modulated waves.

6. Apparatus as recited in claim 5, characterized by the fact that means are provided for rendering inoperative the last circuit for transforming the phase modulated waves into amplitude modulated waves when the first circuit is supplied with phase modulated waves.

7. In a system for demodulating phase or frequency modulated waves, an impedance in which said waves to be demodulated is set up, a filter circuit having an output and having an input coupled to said impedance, the characteristic of said filter circuit being predominantly reactive in the same sense on both sides of its resonance frequency, an electron discharge coupling device having input electrodes coupled to the output of said filter, said electron discharge device having output electrodes, a rectifier having input electrodes and having output electrodes to be coupled to an indicating circuit, a second filter circuit predominantly reactive in the same sense on both sides of its resonance frequency coupled at its input to the output electrodes of said coupling device and at its output to the input electrodes of said rectifier, and means for short-circuiting said last named filter circuit.

8. A system as recited in claim 7 wherein said first filter circuit comprises a piezo-electric crystal in series between said impedance and said coupling device and wherein said second filter circuit includes a piezo-electric crystal in series between the output electrodes of said coupling device and the input electrodes of said rectifier.

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