

March 21, 1939.

R. C. CURTIS

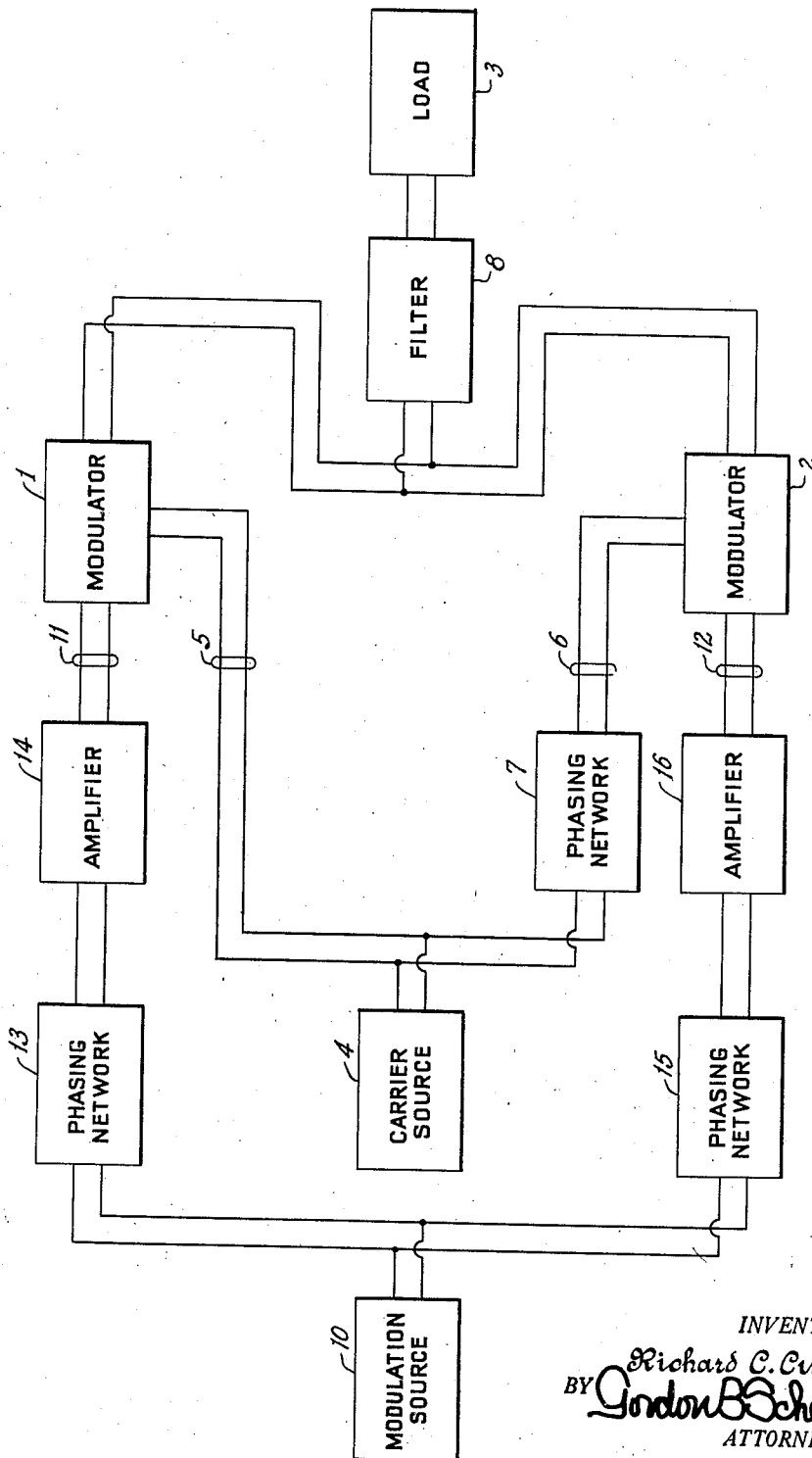
2,151,464

RESTRICTED FREQUENCY TRANSMISSION

Filed July 23, 1937

4 Sheets-Sheet 1

FIG. 1



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FIG. 2

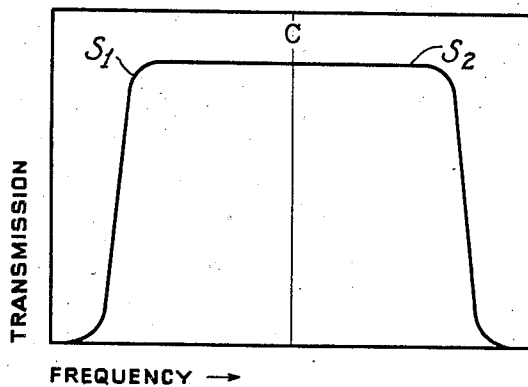


FIG. 3

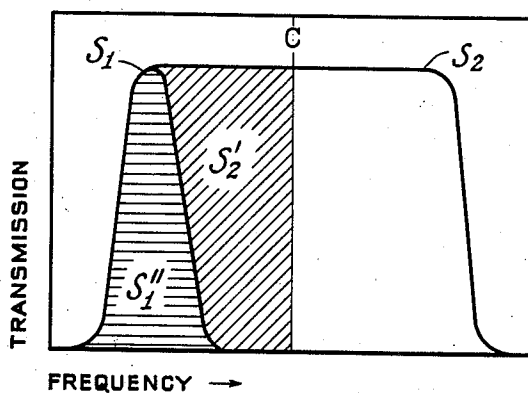
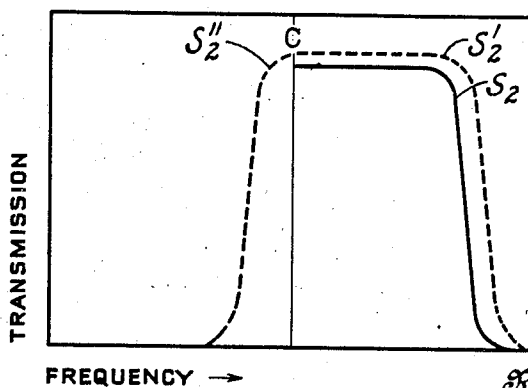


FIG. 4



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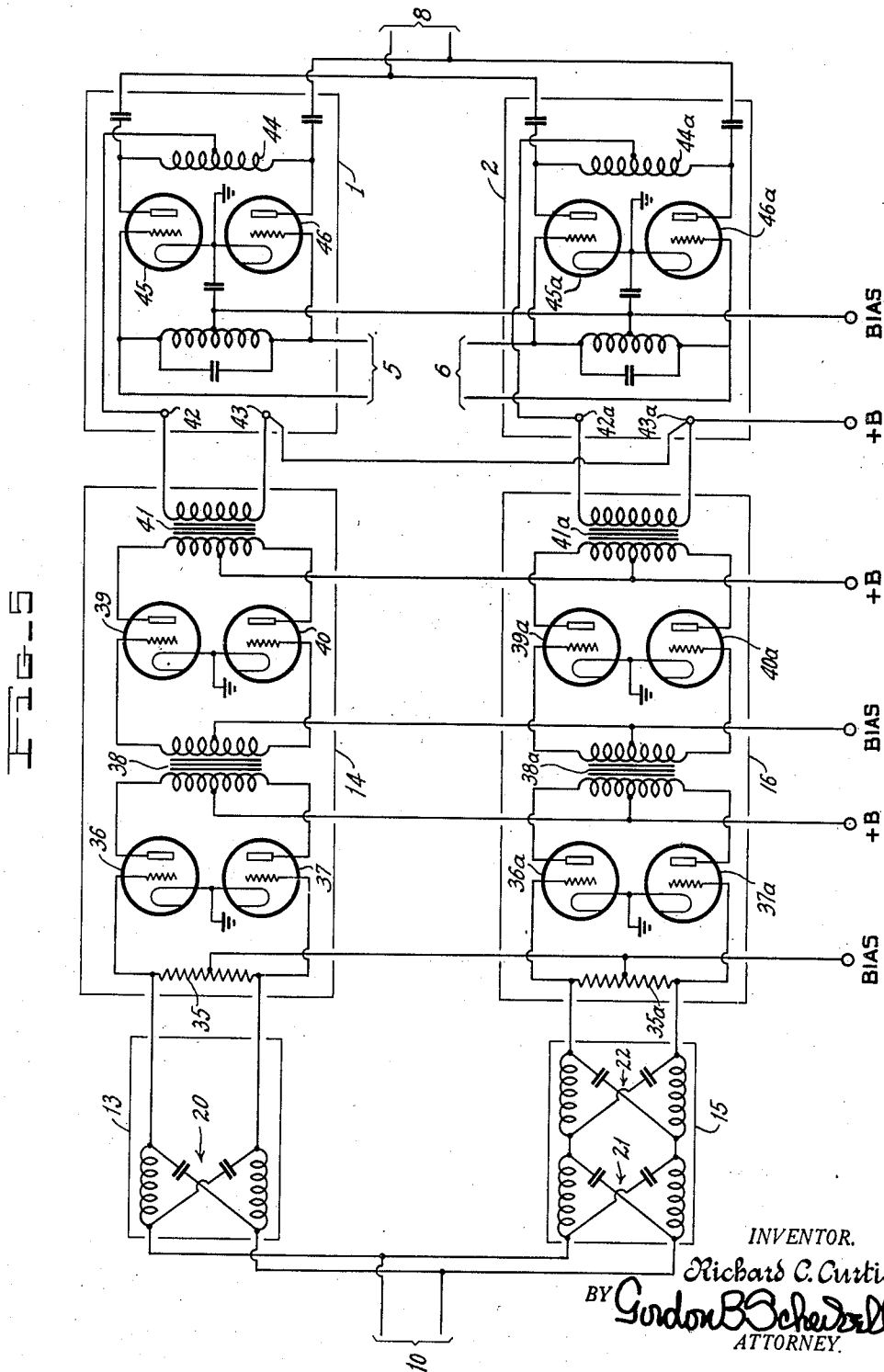
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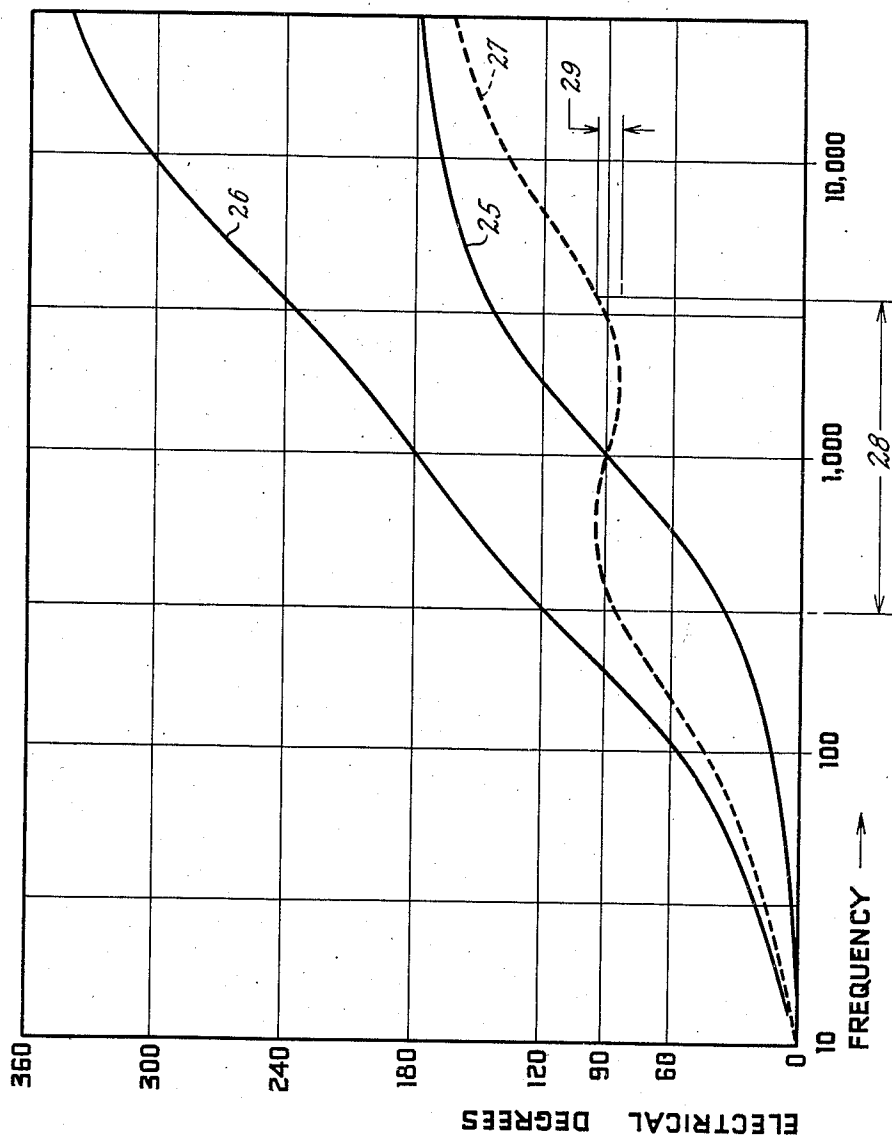
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Fig. 6



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UNITED STATES PATENT OFFICE

2,151,464

RESTRICTED FREQUENCY TRANSMISSION

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Application July 23, 1937, Serial No. 155,213

3 Claims. (Cl. 179—171)

My invention pertains in general to radio transmission systems and specifically relates to an arrangement for transmitting modulated high frequency energy with one modulation side band of frequencies substantially eliminated or suppressed.

The invention contemplates the provision of a system for generating high frequency energy and modulating such high frequency energy with a comparatively wide band of modulation frequencies, and producing therefrom but one effective side band of modulation frequencies. Specifically, the invention embraces a system for eliminating various parts of a side band of modulation frequencies by conjoint wave elimination operations so as to produce modulated high frequency energy having a high fidelity side band of modulated high frequencies and the other side band completely eliminated with a sharp cut-off at the carrier frequency.

The principal object of the invention comprises providing a frequency elimination system for generating modulated high frequency energy and for forming conjoint frequency elimination operations with respect to one of the modulation side bands to eliminate an extensive range of modulation frequencies within the limits of the side band, and at the same time produce a very sharp cut-off adjacent the carrier frequency.

A further object of the invention comprises producing a combined system and method of frequency cancellation and frequency elimination within the range of a single side band in a transmission system.

These and other objects will be apparent from the following, taken in conjunction with the appended drawings, in which like reference numerals designate corresponding parts, and in which:

Fig. 1 is a schematic representation of a restricted frequency transmission system in accordance with a preferred embodiment of the invention;

Fig. 2 is a graphical representation of a double side band transmission range in accordance with the invention;

Fig. 3 is a graphical representation of composite electrical cancellation and discrimination operations in accordance with the system and method of the invention;

Fig. 4 is a graphical representation of a resultant single side band range of frequencies in accordance with the system of the invention;

Fig. 5 is a diagrammatic representation of a circuit employed in the system; and

Fig. 6 is a graphical representation of the operation of circuits depicted in Fig. 5.

The present invention employs a system for producing separate high frequency waves having a substantially ninety degree phase displaced relationship and which are modulated by modulating waves which also have a substantially ninety degree phase displaced relationship. The high frequency waves, amplitude modulated, are combined to produce modulated high frequency energy having side band components substantially extending in but one side band and in a segregated portion of the other side band. In accordance with the invention, this segregated portion of the one side band, which lies in a range remote from the carrier frequency itself, is eliminated by a further process of wave discrimination. It is a feature of the present invention that, by virtue of a composite wave elimination system, it is possible to utilize a wide range of modulation frequencies with the proper phase displacement relationship in the generation of modulated high frequency energy having only single side band frequencies while yet obtaining a sharp cut-off of the unwanted side band at the carrier frequency and, concomitantly, complete elimination of all of the frequencies appurtenant to the unwanted side band.

Referring to the drawings in detail, and particularly to Fig. 1, a pair of modulator units 1 and 2 have their output circuits connected in parallel for feeding through a filter 8 into a load circuit 3. The modulators 1 and 2 receive high frequency energization from a source of carrier energy 4. The carrier source 4 may be any conventional means for producing carrier waves, such as an electron tube oscillator and amplifier. The output circuit of the carrier source 4 is divided into two separate circuit paths 5 and 6. The circuit path 5 delivers carrier frequency energy directly to the modulator 1, while the circuit path 6 includes a phasing network 7 in the form of a suitable phase displacement network which alters the phase angle of the carrier wave traversing the circuit 6, so that, as delivered to the modulator 2, the carrier wave is displaced substantially ninety electrical degrees with respect to the carrier wave delivered to the modulator 1.

A modulation source 10 supplies suitable modulation waves, such as amplified voice currents and the like. The output circuit of modulation source 10 is divided into two circuit paths extending to separate circuit channels 11 and 12, which respectively include the modulators 1 and 2. The

output of modulation source 10, individual to the circuit channel 11, is directed through a phasing network 13 and thence through an amplifier 14 to the modulator 1. The output of modulation source 10, individual to the circuit channel 12, is directed through a phasing network 15 and thence through an amplifier 16 to the modulator 2.

Referring to Fig. 5, it will be seen that the phasing network 13 includes reactive components in the form of inductances and capacitors connected in a lattice formation comprising a section 20. The phasing network 15 is similar to the network 13 but includes a pair of lattice-type sections 21 and 22, connected in series. The essential functions of the phasing networks 13 and 15 are to transmit respectively wide bands of modulation waves, and, in each case, to alter the phase angle of such waves so that the waves have a phase angle other than zero.

In Fig. 6 the curve 25 represents the phase angle of the network 13 plotted with respect to cycles per second, while the curve 26 represents the phase angle of the output waves of the network 15 with respect to cycles per second. The dotted line curve 27 represents the phase difference of the curves 25 and 26. It is a feature of the invention that the constants of the circuits 13 and 15 are adjusted so that the curves 25 and 26 will cause the phase-difference curve 27 to have an approach to horizontal linearity over a wide portion of the audio frequency range as represented by the range 28 in Fig. 6. It will be seen that within the range 28 the curve 27 varies only within the limit of the range 29, which is at approximately ninety electrical degrees. In the representation of Fig. 6, there is a latitude of variation within the range 29 which is plus or minus six degrees, found to be a permissible latitude of variation where a maximum of five per cent of unwanted side band may be tolerated.

The amplifier 14 includes an input resistance 35 (Fig. 5) which forms a terminating impedance for the phasing network 13. The resistance 35 is included in the input circuit to two electron tubes 36 and 37, connected in balanced push-pull formation. The output circuits of the tubes 36 and 37 are connected in push-pull with the primary winding of a coupling transformer 38. The secondary winding of the transformer 38 is connected in push-pull with electron tubes 39 and 40. The output circuits of the tubes 39 and 40 are connected in push-pull with the primary winding of an output transformer 41.

The secondary winding of the output transformer 41 is connected to terminals 42 and 43 in the modulator 1. The terminal 42 is connected to the midpoint of an inductance 44 provided across the output circuit of two push-pull connected electron modulator-type tubes 45 and 46 in the modulator 1. The "grid" input circuit for the tubes 45 and 46 is connected with circuit 5, as will be easily understood from Fig. 1. It will be seen that the modulator 1 is of the "plate" modulation type, the modulation waves being supplied to the output or anode circuit from the amplifier 14.

The amplifier 16 and modulator 2 include components similar to those just described in connection with amplifier 14 and modulator 1, corresponding components in amplifier 16 and modulator 2 having corresponding reference numerals with subscripts "a". Common power supply connections for the electron tubes in the units of Fig. 2 are provided as shown. It will be noted that the terminal 43 is connected with the termi-

nal 43a for the positive anode supply of the modulators 1 and 2.

The output circuits of the modulator 1 and modulator 2 are connected in parallel and directed to the filter 8 and thence to the load 3. The input to the phasing networks 13 and 15 is derived from the modulation source 10. These connections will be readily apparent from an examination of Fig. 1.

In the operation of the system the carrier waves supplied over circuits 5 and 6 to modulator 1 and 2 respectively, have a phase displacement of substantially ninety degrees. The modulation waves supplied to the phasing networks 13 and 15 are subjected to a phase displacing operation, in both instances, so that the phase angle of the output frequencies from each phasing network is greater than zero. It is an essential part of the invention that the parameters of the circuits of the phasing networks 13 and 15 are adjusted to produce respective phase displacement angles such that the difference of the outputs of the two phasing networks 13 and 15 will be very close to ninety degrees within a comparatively wide part of the audio frequency range. This phase relationship is depicted by the dotted line curve 27 in Fig. 6. It will be noted that at ninety electrical degrees this curve departs only a slight amount from horizontal. The latitude of departure is indicated by the range 29. The horizontal extent of the curve 27 within the range 29 is for an appreciable part of the audio frequency spectrum as represented by the range 28. Therefore, in accordance with the invention, modulated high frequency energy delivered to the filter 8, with one side band suppressed is for an extensive useful part of the modulation frequency range.

Fig. 2 represents in a general way the transmission-frequency curve, a carrier wave of frequency C having upper and lower modulation side bands represented by the curves S₁ and S₂ respectively extending on opposite sides of the vertical line graphically representing the carrier frequency. The combined output of the modulators 1 and 2 includes the desired side band and a vestigial side band. In Fig. 3, this desired side band is represented by the curve S₂ and the vestigial side band is represented by the portion S₁' of the side band curve S₁.

From Fig. 3 it will be seen that cooperative action of the combined output of the modulators 1 and 2 produces a substantially "sharp" cut-off at the carrier frequency C so that all of the frequencies within the portion S₂' of the side band S₁ are eliminated.

In accordance with the present invention the waves are combined and operated upon in a composite and sequential method so that not only are those frequencies immediately adjacent the carrier eliminated, but all of the frequencies appurtenant to the undesired side band are eliminated, thereby making it possible to increase the extent of the range of the desired side band. The frequencies in the range S₂ and in the range S₁' are delivered to the filter 3 which has a pass range depicted by the dotted curve S₂' and S₂' in Fig. 4.

The range represented by the curve S₂' and S₂' does not include any of the frequencies within the vestigial side band S₁' although the curve S₂' falls within the range of S₂'. However, the frequencies within this latter range have already been eliminated. The frequencies delivered to the load 3 will be those frequencies represented by the curve S₂ in Fig. 4. These frequencies will

comprise a single side band, which may be of considerable extent, with sharp cut-off at the carrier frequency. All of the frequencies on the unwanted side of the carrier will have been eliminated.

Although a preferred form of carrier and single side band transmission system has been disclosed, it will be recognized by those skilled in the art that various changes and modifications can be made, as, for example, the carrier frequency itself may also be eliminated by the use of an appropriate type of modulator. Accordingly, no limitation is intended except as defined by the scope of the appended claims.

What I claim as new and original and desire to secure by Letters Patent of the United States is:

1. A modulation system comprising, a source of modulations of wide frequency range connected to two branch circuits, all-pass lattice-type dephasing networks in said branch circuits for altering only the respective phase angles of the modulations therein according to different functions of their frequencies, said functions being related to each other so that the phase difference between the modulations in the respective branch circuits is substantially 90 degrees over a large portion of said modulation frequency range; a high frequency carrier source connected to both said branch circuits, means for shifting the relative carrier phase in said connections substantially 90 degrees, means for modulating the carrier in each branch circuit by the respective modulations therein, and means for combining the carriers thus modulated whereby said portion of the modulation frequency range is balanced out of one side band only.

2. A transmission system comprising, cooperating modulation circuits for producing modulated high frequency energy, means for supplying phase displaced carrier frequency energy respectively to said modulation circuits, means comprising all-pass lattice type dephasing net-

works for supplying to said modulation circuits modulation waves having phase angles varying with frequency but with substantially ninety degree phase difference therebetween over a predetermined range for suppressing an intermediate range of frequencies adjacent the carrier in one of the modulation side bands, and wave discrimination means having a pass range extending into said intermediate range and accommodating the frequencies in the other side band but eliminating the above said intermediate range frequencies in said one side band.

3. A transmission system comprising, a modulation source of wide frequency range having two branch circuits, a lattice type dephasing network in one branch circuit for altering the phase angle of the modulations as a function of their frequency, a second lattice type dephasing network in the other branch circuit for altering the phase angle of the modulations as a different function of their frequency, said functions being related to each other so that the phase difference between the modulations in the respective branch circuits is substantially 90 degrees over a large portion of said modulation frequency range, a high frequency carrier source connected to both said branch circuits, means in one of said connections for shifting the carrier phase substantially 90 degrees, means for modulating the carrier in each branch circuit by the respective modulations therein, means for combining the carriers thus modulated whereby a portion only of one side band is balanced out, said portion corresponding to the portion of the modulations having substantially 90 degrees phase difference as aforesaid, and means for filtering out the modulation frequencies above said portion in said one side band whereby only the carrier and other side band containing the full range of modulation frequencies are transmitted.

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CERTIFICATE OF CORRECTION.

Patent No. 2,151,464.

March 21, 1939.

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It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, second column, line 12, claim 2, strike out the word "frequencies" and insert the same before "above" in line 11, same claim; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 16th day of May, A. D. 1939.

Henry Van Arsdale

(Seal)

Acting Commissioner of Patents.