

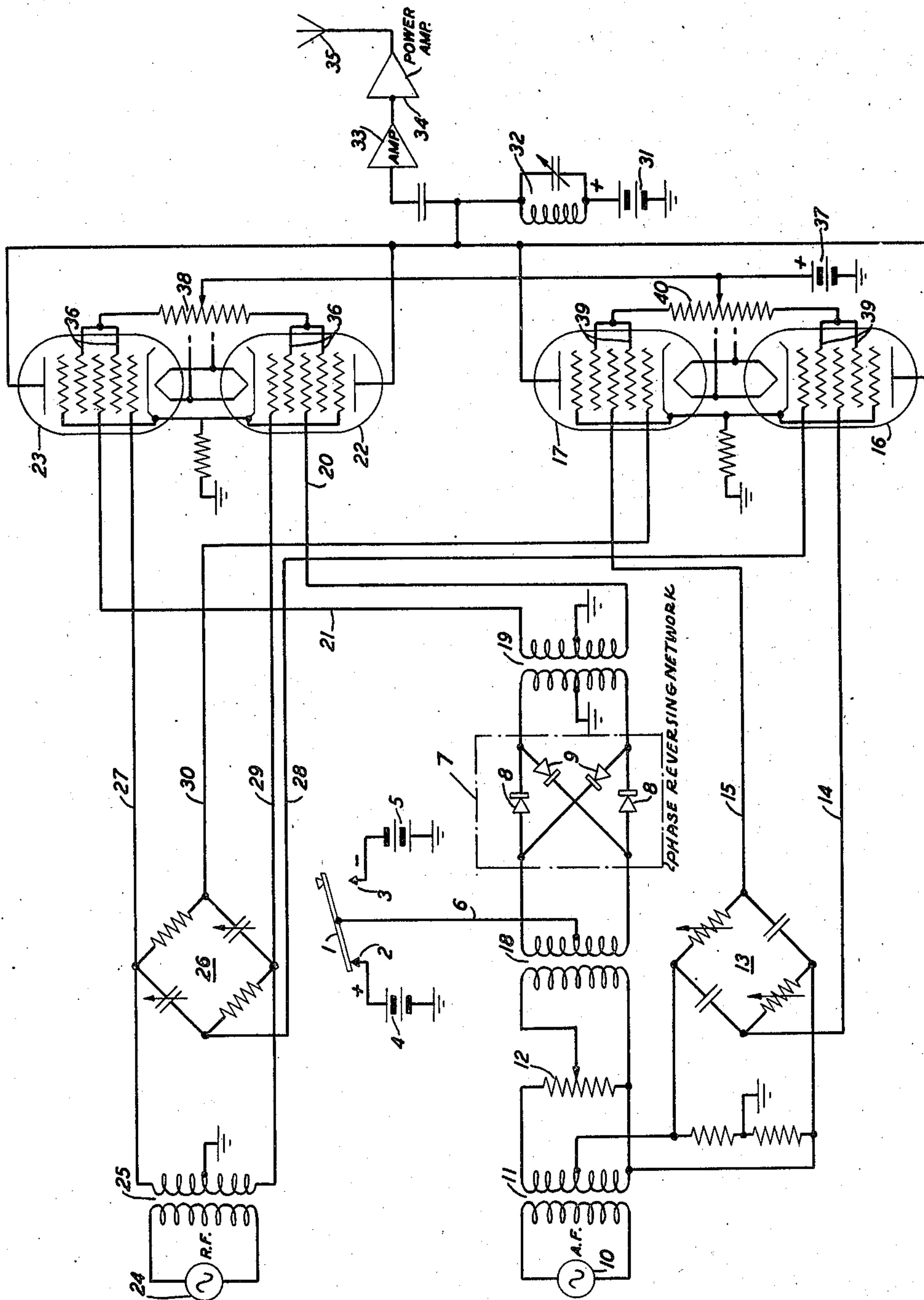
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FREQUENCY-SHIFT RADIO TELEGRAPH TRANSMITTING SYSTEM

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FREQUENCY-SHIFT RADIO TELEGRAPH
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This invention relates to radio transmitting systems and, more particularly, to improved keying means for shifting the frequency of the output waves produced by a radio transmitter back and forth between two different values in accordance with the signals to be transmitted.

Accordingly, it is an object of this invention to provide a radio telegraph transmitting system with improved keying means.

Another object of the invention is to provide a radio telegraph transmitting system with improved means for selectively transmitting alternatively wave energy of two different frequencies which are symmetrically disposed on opposite sides of a base frequency.

A further object of this invention is to provide improved keying means for shifting the frequency of the output waves produced by a radio transmitter back and forth between two different values in accordance with the signals to be transmitted.

These and other objects of the invention are accomplished in a radio telegraph transmitting system by employing phase reversing means for reversing the phase of a portion of the modulating wave energy, used to modulate the carrier wave energy, in accordance with the type of signal to be transmitted at a particular instant. This portion of the modulating wave energy is applied in phase opposition to control grids of a balanced modulator. Another portion of the modulating wave energy, which is not acted upon by the phase reversing means, is passed through a phase shifter and is applied in phase opposition to control grids of a second balanced modulator. The phase shifter is so adjusted that the modulating wave energy applied to the second modulator is in phase quadrature with the modulating wave energy supplied to the first modulator; that is, when the instantaneous alternating value of the voltage is zero in the input to the first modulator, it is a maximum in the input to the second modulator and vice versa. Radio frequency carrier wave energy is also supplied in phase quadrature relation to the modulators. The balanced modulators suppress the carrier wave and tend to produce two side frequencies. However, since their outputs are connected together, one side frequency is cancelled due to the above-mentioned differences in phase. Therefore, only one side frequency will be delivered to the utilization circuit, the particular side frequency delivered at any given instant being determined by the phase of the audio frequency wave energy delivered at that time to the first balanced modulator.

These and other features of the invention are more fully explained in connection with the following detailed description of the single figure of the drawing which illustrates the application

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of the invention to a radio telegraph transmitting system.

In the radio telegraph transmitting system shown in the drawing, telegraph signals of two different types, such as marking and spacing signals, are produced by manually operating the key 1 between its contacts 2 and 3. Positive battery 4 is connected to contact 2 and negative battery 5 is connected to contact 3. Thus, the key 1 constitutes a source of telegraph signals since its operation causes direct current polar telegraph signals, consisting of direct current which flows in one direction for marking and in the other direction for spacing, to be transmitted along conductor 6 to the phase reversing network 7. It is to be understood that any other suitable means may be employed for producing telegraph signals and applying them in the form of positive or negative current to the phase reversal network 7. The phase reversal network 7 comprises two pairs of voltage sensitive variable resistance elements, such as copper oxide disc rectifiers 8, 8 and 9, 9, connected in the manner shown in the drawing so that the pair of rectifiers 8, 8 present a low resistance to positive current from conductor 6 and a high resistance to negative current while the pair of rectifiers 9, 9 present a low resistance to the flow of negative current from conductor 6 and a high resistance to positive current.

An audio frequency generator 10 of any suitable design produces wave energy having a frequency of 425 cycles. One portion of this wave energy is supplied by a transformer 11 to a potentiometer 12 and another portion is delivered by the transformer 11 to a phase shifter 13. The phase shifter 13 is a bridge network comprising condensers and resistances designed to shift the phase of the voltage of the wave energy supplied thereto by transformer 11 so that the voltage in conductor 14 will be 90 degrees displaced from the voltage in the primary winding of the transformer 11 while the voltage in conductor 15 will be displaced 270 degrees. The voltage having a phase shift of 90 degrees is delivered by conductor 14 to a grid of a tube 16 and the voltage having a phase shift of 270 degrees is applied by conductor 15 to a grid of a tube 17. The voltages in conductors 14 and 15 are approximately equal. Tubes 16 and 17 constitute a balanced modulator as will be discussed in more detail hereinafter.

The portion of the audio frequency wave energy supplied to the potentiometer 12, after having its level adjusted, is delivered by another transformer 18 to the phase reversing network 7 which acts as a reversing switch. For example, if key 1 is in the position shown in the drawing, then positive current will flow in conductor 6 to the secondary winding of transformer 18. Here

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it will divide evenly and will flow through the pairs of copper oxide discs 8 and 9 in such a direction as to decrease the resistance of the series pair 8 while increasing the resistance of the shunt or cross pair 9. This permits the audio frequency current to pass straight through the network 7 from transformer 18 to a transformer 19. When this occurs, transformer 19 delivers some of this audio frequency wave energy over a conductor 20 to a grid of a tube 22, the voltage of this portion being 180 degrees out of phase with that in the primary winding of the transformer 11. Another portion is supplied over a conductor 21 to a grid of a tube 23, the voltage of this portion being in phase with that in the primary winding of the transformer 11. The voltages in conductors 20 and 21 are approximately equal. These two tubes 22 and 23 constitute another balanced modulator.

On the other hand, if key 1 is operated against its contact 3, then negative current will flow in conductor 6 to the secondary winding of the transformer 18 where it will divide evenly and will flow through the pairs of copper oxide discs 8 and 9 in the reverse direction so that the resistance of the series pair 8 will increase and the resistance of the shunt or cross pair 9 will decrease. This will cause the audio frequency current to take a reversed circuit path just as if a reversing switch had been operated. Therefore, the voltage of the energy now flowing along conductor 20 will be in phase with that in the primary winding of the transformer 11 while the voltage of the energy now flowing over conductor 21 will be 180 degrees out of phase. Thus, as the key 1 is operated to one or the other of its contacts 2 and 3 in accordance with the marking and spacing telegraph signals to be transmitted, the phase reversing network 7 functions as a reversing switch to reverse the phase of the audio frequency inputs to the balanced modulator constituted by the tubes 22 and 23.

It should also be noted that the modulating voltage applied to tube 22 is always 90 degrees out of phase with the modulating voltage applied to tube 16, and the voltage applied to tube 23 is always 90 degrees out of phase with the voltage applied to tube 17. In other words, a quadrature phase relation is always maintained between the audio frequency inputs to the balanced modulator tubes 16, 17, 20, and 21.

A radio frequency oscillator 24 of any appropriate design produces wave energy having a frequency of 2,000,000 cycles. It is to be understood that this specific value and the specific value of the audio frequency wave energy have been set forth for purposes of explanation and that the invention is not restricted to these specific values.

This wave energy is supplied by means of a transformer 25 to a phase shifter 26 which is a bridge network comprising condensers and resistances. This phase shifter 26 is designed to produce a 90 degree phase difference between the voltages at its output terminals so that the voltage of the wave energy flowing along the conductor 27 is in phase with that in the primary winding of the transformer 25, while the voltage in conductor 28 is 90 degrees out of phase, that in conductor 29 is 180 degrees out of phase, and that in conductor 30 is 270 degrees out of phase. The voltages in these four conductors are approximately equal.

As conductor 27 is connected to a grid of tube 23 and conductor 29 is connected to a grid of tube 22, the balanced modulator constituted by tubes

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22 and 23 is supplied with two portions of the radio frequency energy which are 180 degrees out of phase. Similarly, since conductor 30 is connected to a grid of tube 17 and conductor 28 is connected to a grid of tube 16, the balanced modulator constituted by tubes 16 and 17 is supplied with two other portions of the radio frequency energy which are also 180 degrees out of phase. There is thus a quadrature phase relation between the four radio frequency inputs to the balanced modulators.

It is to be noted that both the radio frequency input and the audio frequency input to tube 16 are always 90 degrees out of phase with their respective generator outputs while both the radio frequency and audio frequency inputs to tube 17 are always 270 degrees out of phase. In other words, both inputs to tube 16 are always 180 degrees out of phase with the corresponding inputs to tube 17.

The radio frequency input to tube 23 is always in phase with its source but the audio frequency input to tube 23 is either in phase with its source or 180 degrees out of phase depending on whether the key 1 is engaging its contact 2 or its contact 3. The radio frequency input to tube 22 is always 180 degrees out of phase with its source while the audio frequency input to tube 22 is either 180 degrees out of phase with its source or in phase depending on the position of the key 1. Thus, if the key 1 is operated against its contact 2, then both the radio frequency and audio frequency inputs to tube 23 will be in phase with their respective sources and both inputs to tube 22 will be 180 degrees out of phase with their respective sources and also 180 degrees out of phase with the corresponding inputs to tube 23. However, if the key 1 is operated against its contact 3, then, while the radio frequency input to tube 23 remains in phase with its source, the audio frequency input will be 180 degrees out of phase with its source and the radio frequency input to tube 22 will remain 180 degrees out of phase with its source while the audio frequency input will now be in phase with its source. In either case, there is always a 180-degree phase difference between the radio frequency inputs to tubes 22 and 23 and also there is always a 180-degree phase difference between the audio frequency inputs to tubes 22 and 23.

The anodes of tubes 16, 17, 22, and 23 are connected in parallel and are supplied with positive current from battery 31 through a tuned circuit 22 which is tuned to the radio frequency. The parallel output circuits of the balanced modulators are connected to an intermediate amplifier 33 which has its output connected to the final power amplifier 34. The amplified signals from the power amplifier 34 are delivered to the transmitting antenna 35 which radiates them through space.

In order to adjust the audio frequency input to obtain a balance of the resultant side frequencies in operating this radio transmitting system, the potentiometer 12 is so adjusted as to cause the amplitude of the side frequencies produced in the balanced modulator constituted by the tubes 22 and 23 to be approximately equal to the amplitude of the side frequencies produced in the balanced modulator constituted by the tubes 16 and 17.

The screen grids 36 of the balanced modulator constituted by tubes 22 and 23 are supplied with positive voltage from battery 37 through a potentiometer 38 and the screen grids 39 of the bal-

anced modulator constituted by tubes 16 and 17 are similarly supplied with positive voltage from battery 37 through a potentiometer 40. In order to enhance the balance of each of the balanced modulators, in adjusting for a balance between the radio frequency outputs, both the potentiometers 38 and 40 are adjusted to supply the screen grids 36 and 39, respectively, with voltages of the proper magnitudes so that the carrier wave, or base radio frequency of 2,000,000 cycles, will be suppressed in a manner well known to those skilled in the art.

During signaling periods, the radio frequency and audio frequency wave energies are supplied to each balanced modulator in a push-pull manner so that in each balanced modulator the potential on the grid of one of the modulator tubes is positive while the potential on the grid of the other tube is negative at any particular instant. Since the two modulators can be adjusted for a nearly perfect balance in the manner described above, the output currents in the parallel-connected output circuits of the modulators will therefore neutralize or balance each other in a manner well known to those skilled in the art so that the radio frequency carrier wave of 2,000,000 cycles will be suppressed or eliminated. However, the output of each balanced modulator will contain upper and lower side frequencies of 2,000,425 cycles and 1,999,575 cycles due to the modulation of the radio frequency wave energy by the audio frequency modulating energy.

Because of the above described 90-degree phase differences between both the radio frequency and the audio frequency inputs to the modulator tubes, one of the side frequencies will be suppressed. To select which side frequency is to be transmitted and which is to be balanced out, it is only necessary to select the phase of the audio frequency input to the balanced modulator constituted by the tubes 22 and 23. This is accomplished by controlling the operation of the phase reversing network 7 by means of the telegraph signals supplied thereto from the sending key 1.

For example, when the key 1 is operated to its contact 2 to effect the transmission of a spacing signal, the lower side frequency waves produced by both balanced modulators will have a zero phase difference, whereas the upper side frequency wave produced by one balanced modulator will be 180 degrees out of phase with the upper side frequency wave produced by the other balanced modulator. This can be seen from the following table of the side frequency phase differences existing at this time. In the following table, the values in column 3 are the sums of the corresponding values in columns 1 and 2 while the values in column 4 are the differences between the corresponding values in columns 1 and 2:

	1	2	3	4
	A. F.	R. F.	Upper Side Fre- quency	Lower Side Fre- quency
	Degrees	Degrees	Degrees	Degrees
Tube 23.....	0	0	0	0
Tube 22.....	180	180	0	0
Tube 17.....	270	270	180	0
Tube 16.....	90	90	180	0

Since the output circuit of the second balanced modulator is connected in parallel with the output circuit of the first balanced modulator, the upper side frequency will be canceled, or bal-

anced out, and only the lower side frequency will be supplied at this time to the antenna 35 for radiation.

When the key 1 is operated to its contact 3 to effect the transmission of a marking signal, the upper side frequency waves produced by both balanced modulators will be in phase with each other but the lower side frequency wave produced by one balanced modulator will be 180 degrees out of phase with the lower side frequency produced by the other balanced modulator. This is shown by the following table of the side frequency phase differences which are now present:

	A. F.	R. F.	Upper Side Fre- quency	Lower Side Fre- quency
	Degrees	Degrees	Degrees	Degrees
Tube 23.....	180	0	180	180
Tube 22.....	0	180	180	180
Tube 17.....	270	270	180	0
Tube 16.....	90	90	180	0

At this time, the lower side frequency will be canceled and only the upper side frequency will be delivered to the antenna 35.

Thus, by means of this frequency shift keying circuit, the antenna 35 will transmit wave energy having either a frequency of 2,000,425 cycles or a frequency of 1,999,575 cycles in accordance with the marking and spacing polar telegraph signals selectively produced by the key 1.

What is claimed is:

1. A carrier shift telegraph transmitting system comprising in combination a source of carrier waves, a source of low frequency oscillations, a pair of balanced modulators having a common output circuit, a plurality of input circuits for coupling each of said sources with said modulators for impressing thereon said carrier waves and said low frequency oscillations in such phase relationships as to produce a single side frequency in said common output circuit, said system being characterized by having control means for changing the wavelength of said single side frequency in accordance with telegraph signals, said control means including a telegraph key, a source of bias voltages, phase reversing means interposed in one of said input circuits, and circuit means for impressing the biasing voltages on said phase reversing means for reversing the phase of the electric wave energy impressed by said input circuit in accordance with the operation of said telegraph key.

2. A carrier shift telegraph transmitting system comprising in combination a source of carrier waves, a source of low frequency oscillations, a pair of balanced modulators having a common output circuit, a plurality of input circuits for coupling each of said sources with said modulators for impressing thereon said carrier waves and said low frequency oscillations in such phase relationships as to produce a single side frequency in said common output circuit, said system being characterized by having control means for changing the wavelength or said single side frequency in accordance with telegraph signals, said control means including a telegraph key, a source of bias voltages, phase reversing means comprising a Wheatstone bridge structure of voltage sensitive variable resistance elements interposed in the low frequency input circuit of one of said modulators, and circuit means for impressing the biasing voltages on said variable resistance elements for unbalancing the bridge in one direction

when said key is in one position and for unbalancing the bridge in the other direction when said key is in another position.

3. A carrier shift telegraph transmitting system comprising in combination a source of carrier waves, a source of low frequency oscillations, a pair of balanced modulators having a common output circuit, a plurality of input circuits for coupling each of said sources with said modulators for impressing thereon said carrier waves and said low frequency oscillations in such phase relationships as to produce a single side frequency in said common output circuit, a telegraph signal source for producing marking and spacing polar telegraph signals alternatively, said system being characterized by having control means for changing the wavelength of said single side frequency from one value when marking signals are produced by said telegraph signal source to another value when spacing signals are produced, said control means comprising a phase reversing network interposed in one of said input circuits, and circuit means for impressing said marking and spacing polar telegraph signals on said phase reversing network, said phase reversing network comprising four voltage sensitive variable resistance elements connected in a lattice structure, one pair of said elements being connected for presenting a low resistance to marking signals and a high resistance to spacing signals and the other pair of said elements being connected for presenting a low resistance to spacing signals and a high resistance to marking signals.

4. A single sideband modulating system having in combination a source of carrier waves, a source of single frequency audio waves, a first balanced modulator comprising two electronic tubes, a second balanced modulator comprising two other electronic tubes, said modulators having a common output circuit, first circuit means for applying said carrier waves to said four electronic

tubes in phase quadrature, second circuit means for applying said audio waves to the two tubes of one modulator in phase opposition, third circuit means for applying said audio waves to the two tubes of the other modulator in phase opposition, phase shifting means for establishing a phase quadrature relation between said audio inputs to said four tubes whereby the carrier and one sideband are suppressed and only one sideband appears in said output circuit, said system being characterized by having control means for interchanging the suppressed sideband and the sideband appearing in said output circuit, said control means comprising a source of bias voltage, a phase reversing network interposed in said second circuit means for reversing the phase of the audio waves applied by said second circuit means, said phase reversing network comprising a Wheatstone bridge structure of four voltage sensitive variable resistance elements, and means for applying said bias voltage to said phase reversing network for reversing the balance of said Wheatstone bridge structure of said resistance elements whereby the phase of the audio waves applied by said second circuit means to the two tubes of one modulator is reversed.

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