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SINGLE SIDE BAND TRANSMISSION

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Fig. 1

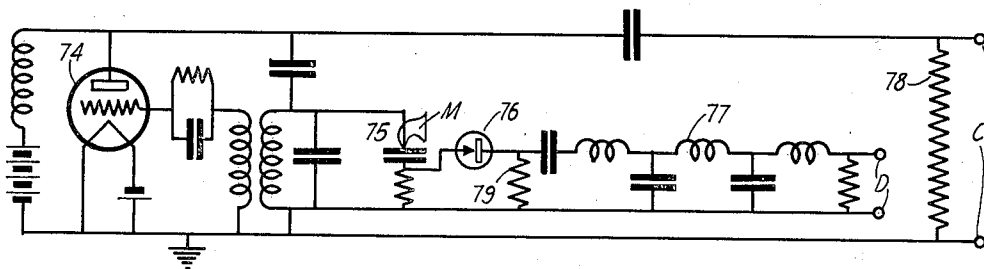
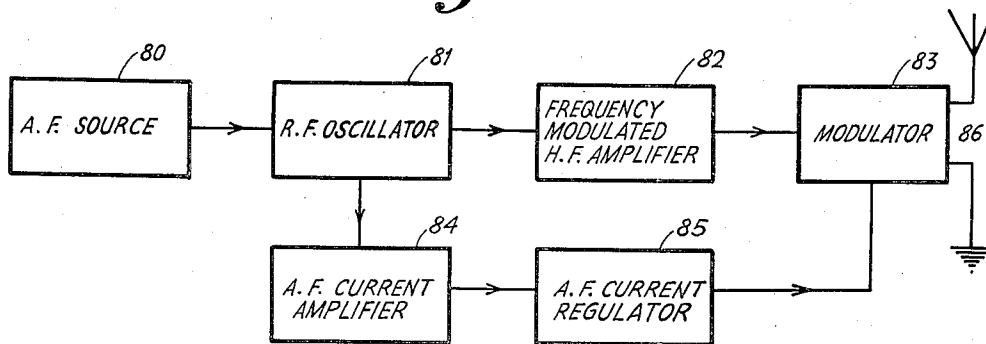


Fig. 2



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SINGLE SIDE BAND TRANSMISSION

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No. 480,165. Divided and this application Sep-
tember 6, 1935, Serial No. 39,361

3 Claims. (Cl. 179-171)

This invention relates to methods of single side band transmission. More particularly it relates to the production of a transmission consisting of a single side band or a single side band and a carrier in which the frequency components radiated are produced synthetically by various high frequency components modified in various manners as will be more clearly set forth hereinafter. The present application is a division of my copending application Serial No. 480,165, filed September 6, 1930 now U. S. Patent No. 2,020,327.

The usual type of radio transmission by voice modulation methods, as is well known, utilizes a carrier wave and two side bands, one on each side of the carrier wave. It is well known that a system involving a carrier wave and one side band only, is superior to the usual system as respects: (1) tone quality, since the beating of the side bands with each other is thereby eliminated; (2) freedom from fading, since the phase relations of the carrier and side bands cannot be differentially disturbed to give at certain times, phase opposition of the currents produced by beating of the carrier on one side band with respect to that produced by beating produced by the other side band; and, (3) less spectral space is required for transmitting a signal capable of being received by the usual type of radio receiver.

Further, single side band transmission gives even greater advantages over carrier and single side band transmission with respect to quality, fading, and compactness of radiation, with the further advantage of greater transmission range per watt of the transmitter power.

The development of carrier and single side band circuits, although acknowledged to be desirable, has not come about because of the complexity of the circuits required, involving radio frequency filters of a great degree of selectivity and also requiring several stages of modulation. The development of single side band circuits at present meets with the same difficulties.

It is the object of this invention to provide methods and systems for producing carrier and single side band radiation.

It is, more particularly, the object of this invention to overcome the above noted difficulties and provide direct means for producing carrier and single side band radiation without the use of multiple stages of modulation and radio frequency filtering.

It is a further object to produce single side band transmission by utilizing the single side band and carrier methods in push-pull arrangement of two circuits whereby the single side bands become additive and carriers neutralize each other.

These and further objects will become apparent from the following specification taken in connection with the appended drawing.

Four methods are involved in this invention as follows:

1. The combination of amplitude modulation and phase modulation.
2. The combination of amplitude modulation and frequency modulation.
3. Separate amplitude modulations involving reversal of one of the side bands produced and combining of the two spectra in various manners.
4. Direct amplitude modulation by methods utilizing two phase sources for the modulated and modulating frequencies.

The last mentioned method is being covered in my copending application Serial No. 480,166, filed September 6, 1930 now U. S. Patent No. 1,994,048 filed concurrently herewith, and is being included in this description merely for the purpose of co-ordination of the various systems. The present specification therefore, principally concerns itself with methods 1, 2 and 3.

For the two simultaneous methods outlined above under methods 1 and 2, there are required the following:

For method 1, means for the simultaneous phase and amplitude modulation of a carrier wave with the extent of phase modulation in radians from the mean value equal to the degree of amplitude modulation but with the two modulations quadrature related.

Method 2 requires means for the simultaneous frequency and amplitude modulation of a carrier wave with the two modulations produced in phase, and with the extent of the frequency variations from the mean equal to the degree of amplitude modulation multiplied by the frequency of modulation.

Method 3 may be divided into three combinations as follows:

A. Means for producing an amplitude modulated wave form with carrier and two side bands, means for producing a wave form similar to the above wave form with all three equivalent waves of equal magnitude in the two wave forms, but with one side band of one wave form in phase opposition with the corresponding side band in the other wave form, and means for combining the two wave forms by addition whereby one side band will be eliminated and the other side band and the carrier will remain.

B. Means for producing a wave composed of a carrier and two side bands by the usual amplitude modulation methods, means for producing a wave of carrier and two side bands similar to the above, except that one side band of one wave form must be equal and of opposite phase to the corresponding side band of the other wave form, and means for the subtraction of the two wave forms whereby the carrier and one side band will be eliminated, resulting in the production of a wave composed of a single side band,

C. Means for producing a composite wave form by the carrier suppression system consisting of two side bands only, means for producing similar composite wave by the carrier suppression system with the two side bands only, and with one side band of this wave form equal and opposite to the corresponding side band of the other wave form, and the other side band equal to the corresponding side band in the other wave form, and in phase therewith, and means for addition whereby one side band is eliminated, and there is thus produced a wave form comprising a single side band.

For methods 1 and 4, as given above, namely the method involving combined phase and amplitude modulation, and the method involving producing two phase sources of modulated and modulating frequencies, a necessary tool is a means for producing a two phase audio frequency source from a single phase audio frequency source. With a single frequency audio source, a two phase current may be readily produced, but with a band of from 250 to 4,000 cycles or about 4 octaves, certain difficulties though encountered are nevertheless overcome by the methods of the present invention and that of my copending application noted above.

One method of producing a two phase audio current which will be described in the present application, involves stepping up the frequency of the speech band to an intermediate frequency band by the usual push-pull method and then filtering to produce the desired phase lag. Thus a band of 250 to 4,000 cycles could be used to modulate the 6,000 cycle current and the side band of from 6,250 to 10,000 cycles retained. A suitable modulator for accomplishing this is disclosed in my copending application, Serial No. 364,222, filed May 18, 1929, Patent No. 1,984,156, December 11, 1934. A filter of high pass construction having a cut off at 6,125 cycles may be rather easily constructed.

The 6,000 cycle current is split into two phases and a single side band passed through the filter is combined separately with one of the phases of the 6,000 cycle current. As a result, the detecting currents are of the original audio frequency but quadrature related for all frequencies and of the same output at all frequencies.

Having thus briefly described my invention, attention is invited to the accompanying drawing in which:

Fig. 1 represents a circuit for producing related audio frequency amplitude modulated and frequency modulated high frequency current and corresponds to Figure 7 of said Patent No. 2,020,327.

Fig. 2 is a general diagram of a transmitter involving the principle of related frequency and amplitude modulation of a carrier frequency current and corresponds to Figure 8 of said Patent No. 2,020,327.

For an explanation of the true nature of phase modulation and frequency modulation in comparison with amplitude modulation, reference should be made to the brief analysis of this subject which is given in said U. S. Patent No. 2,020,327.

Referring now to Fig. 1, there is shown an arrangement for obtaining an audio frequency current for modulation purposes which is in phase with corresponding frequency variations. This circuit comprises a source of high frequency energy including an oscillator 74 and its associated circuits. Included in the frequency de-

termining circuit of the oscillator 74 is the condenser microphone 75 which is thus adapted to vary the frequency produced by the said oscillator in accordance with the voice impulses. In series with the condenser microphone 75 is the impedance 79 through which the current will be proportional to the displacement of the condenser microphone diaphragm, or in other words, will vary in accordance with the voice impulses. The output of the oscillator is across the impedance 78 and frequency modulated high frequency energy may be supplied by the terminals C to the proper amplifying devices before combining or remodulating, as will be described hereinafter.

Impedance 79 serves to supply the combined amplitude and frequency modulated high frequency current to a filter 77 arrangement which includes in its input a rectifier 76. The output terminals D of the filter 77 are thus supplied with a direct current, the intensity of which varies in accordance with the voice frequency.

As the capacity of the condenser microphone changes, not only will the frequency of the modulator frequency change, but also there will be changes in the amount of the high frequency alternating current passing through the microphone and through the impedance 79. Therefore, through this impedance is a current of varying amplitude of varying frequency with the two variations occurring simultaneously, since both the frequency and the current depend upon the value of the capacity of the condenser microphone. However, the amplitude and frequency changes are directly proportional so that the current in 79 is not the equivalent of the carrier and a single side band for all rates of frequency change. The current flowing through 79 by means of the detector 76, and filter 77, to remove the radio frequency components, causes a current to flow through the output impedance and thus produces a varying audio current voltage across the terminals D. This audio frequency voltage will correspond with the rate and extent of the radio frequency changes caused by the condenser microphone 75.

While the production of an audio voltage, which is in phase with the frequency variation, is easily accomplished, it is further necessary for my purposes to regulate the relative amount of audio current so that the amplitude modulation may be greater at the higher frequencies. This regulating must be such that the phase of the amplitude modulation and of the frequency modulation will be the same in the radiated wave. This may be done along the general lines of using two phase shifts, one in the mechanism that produces an audio current with certain phase relationship, in other words, in the filter 77 and of strength relative to the frequency modulation, and one in the mechanism that regulates the audio current for producing the greater amplitude modulation of the higher frequencies.

Referring now more particularly to Fig. 2, there is shown a schematic diagram of means for combining the frequency modulated and the amplitude modulated high frequencies to produce a transmission comprising a single side band. Here the audio frequency source 80 acts upon the radio frequency oscillator 81 to produce a wave varied in frequency which wave is amplified by the amplifier 82, and also to produce an audio current having a definite relation to each frequency present as to its strength and phase with respect to the audio frequency variation in the radio

frequency. That is, in general the audio currents need not be absolutely in phase with the rates of variation in radio frequency nor need the amplitude be proportional to the amount of radio frequency variation. The audio frequency current however, is amplified in the amplifier 84 and scaled as to intensity in a regulating device 85, which is used to shift the phase and regulate the amplitude of the different frequencies.

10 The audio current, thus scaled, is used to modulate in the modulator 83 the radio frequency which has been frequency modulated and amplified by the amplifier 82.

15 The degree of accurate elimination of the side band would depend upon how correctly the amplitude variations have been related to the frequency variations. Probably the most accurate method of producing single side band transmission is by the fourth method listed at the beginning of this specification which, as has been noted, is covered in my copending application Serial No. 280,166, filed concurrently herewith now U. S. Patent No. 1,994,048. This method, which utilizes two phase source of modulating and modulated currents with amplitude modulation methods, permits using well known methods of construction except as to the phase splitting of the speech band.

20 The mathematical basis of the process involved in this invention is shown by the equation:

$$\sin(pt + \theta) \cos(wt + \phi) + \cos(pt + \theta) \sin(wt + \phi) = \sin[(w + p)t + (\phi + \theta)]$$

25 The first term is the first radio phase push-pull modulated by the first speech phase, and the second term is the second radio push-pull modulated by the second speech phase. The sum of the two terms is a single side band current.

30 It is obvious that by changing the method of combining the two phase radio and two phase audio currents, either the upper or lower side band can be obtained as desired. By permitting some of the carrier through or by passing it to the circuit subsequent to the push-pull modulation, it is evident that the carrier could be transmitted together with the single side band. This method, however, need not further be described here.

35 Having thus described my invention, attention is invited to the fact that various modifications may occur which fall within its scope, and that I am therefore not to be limited to the specific embodiment described and shown for the purpose of illustration, but by the actual scope of my invention as determined and set forth in the appended claims.

40 1. In a signalling system, means for generating high frequency energy, said last named means including a frequency determining variable reactance device, means for varying the variable reactance in accordance with the signal energy desired to be transmitted to thereby vary the frequency of the generated high frequency energy and cause a flow of high frequency energy through the reactance which varies simultaneously both in frequency and in magnitude, a non-selective impedance element in series with the variable reactance and arranged so that the high frequency energy passing through the reactance also passes through the non-selective impedance element whereby there is developed a potential

45 across the impedance, rectifying means connected across the last named element and arranged so as to produce a flow of direct current the intensity of which varies in accordance with the original signalling energy and also with the departure of the frequency of the generated high frequency energy from a predetermined normal frequency value, means for filtering the output from the rectifier, a corrective network connected across the filtering means, said corrective network acting to make the voltage of the signal current relative to the impressed signal voltage vary with the signal frequency in a predetermined manner and means for amplitude modulating the original frequency modulated high frequency energy in accordance with the output of the corrective network.

50 2. Means for obtaining a signal current for modulation purposes which is substantially in phase with corresponding frequency variations of a high frequency wave comprising, means for generating high frequency energy, a frequency determining circuit associated with said generating means said frequency determining circuit including a variable reactance device and a non-selective impedance element in series, said variable reactance device being adapted to be varied in accordance with signal energy to thereby vary the frequency of the generated high frequency energy and cause a flow of high frequency energy through the reactance device and the non-selective impedance element varying simultaneously both in frequency and in magnitude in accordance with the signal energy, an output impedance device connected across the frequency determining circuit, frequency modulated high frequency energy being available across said output impedance device, a rectifier circuit having its input connected across the impedance element, a filter circuit connected across the output of the rectifier circuit, said filter circuit being arranged to remove high frequency components from the rectifier output, an impedance element connected across the filter circuit, the energy available across said last named impedance being in phase with the frequency variations of the frequency modulated high frequency energy available across the said output impedance device.

55 3. In an arrangement for obtaining a signal current for modulation purposes which is substantially in phase with corresponding frequency variations comprising, an oscillator circuit including an electronic tube having an anode, a cathode and a control electrode, external circuits for said tube including a control electrode-cathode circuit and an anode-cathode circuit, said two circuits being coupled so as to facilitate transfer of energy from one to the other to thereby produce oscillations, said anode to cathode circuit including a frequency determining circuit comprising a condenser microphone and a non-selective impedance element in series, an output circuit for said oscillator comprising a load impedance device connected between the anode and cathode of the tube, a rectifying circuit including said non-selective impedance, a rectifier tube and a load impedance device in series, a filter circuit connected across the last named impedance device and an output impedance connected across the output of the filter circuit.

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