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RADIO SIGNALING SYSTEM

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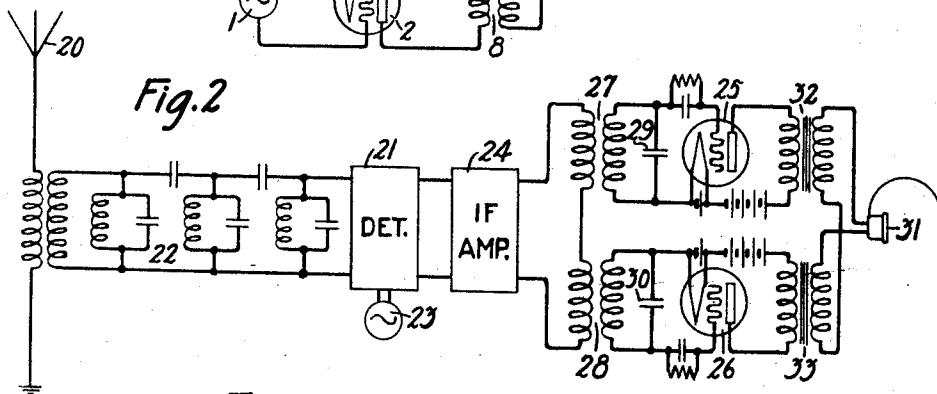
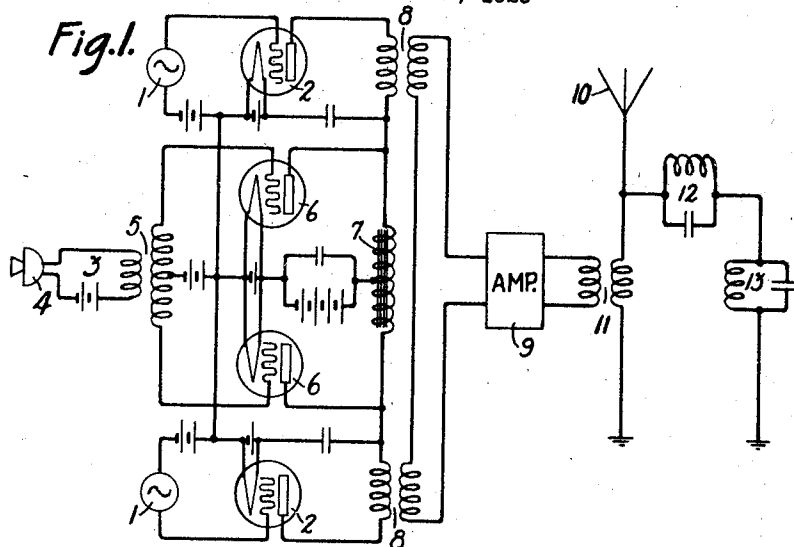
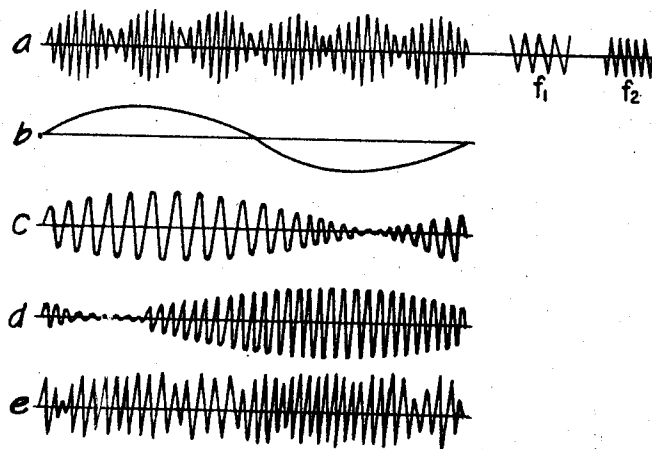


Fig. 3.



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RADIO SIGNALING SYSTEM

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This invention relates to signaling systems and more particularly to short-wave radio communication systems.

It has been observed that waves of frequencies as near together as 10,000 or 15,000 cycles in the region of 4,500,000 cycles do not fade simultaneously. The periods of maximum and minimum intensity of the two waves do not coincide nor can they be observed to obey any rule of occurrence in relation to one another. The quality of a received signal appears to be poor only at those instants when the carrier wave has faded to a small amount. In this case the two side bands produce double frequency notes, while the carrier is too small to combine with the side bands for the purpose of producing the fundamental frequencies of modulation.

In order to obtain good quality it is necessary that the amplitude of the carrier be large with respect to that of the side bands. Consequently, by transmitting the same signal on two different carrier waves differing in frequency by a few thousand cycles, the probability of the two carrier waves fading to a negligible amount simultaneously is considerably less than that of a single carrier. By increasing the number of carrier waves on which the same signal is transmitted to three or more, the probability of all the carriers fading to zero at the same time is still further reduced.

It is an object of this invention to minimize the effect of fading in radio transmission.

Another object is to provide for the efficient use of high power transmitting tubes.

These objects, and others will be apparent as the nature of the invention is disclosed, are accomplished by employing a plurality of transmission channels operating at a frequency of the order of four or five million cycles, the various channels differing in frequency by at least a few thousand cycles, for example, in a specific case, by 10,000 cycles.

In a system of this type, efficient use is made of the transmitting power tubes by modulating the carrier waves of the two channels with speech waves in opposite phase, the result being that as the power in one channel is increased, the power in the other channel is

decreased. When currents from the two channels are impressed upon the same amplifier the intensity variation produced by modulation will be considerably less than that in either channel alone as will be pointed out hereinafter.

Although the novel features which are believed to be characteristic of this invention will be pointed out with particularity in the claims appended hereto, the invention itself, its objects and advantages, the mode of its organization and the manner of its operation will be better understood by referring to the following description taken in connection with the accompanying drawings forming a part thereof, in which;

Fig. 1 shows diagrammatically transmitting apparatus constructed in accordance with this invention;

Fig. 2 shows a receiving set adapted to cooperate therewith; and

Fig. 3 shows a plurality of curves to be used in explaining the operation of the system disclosed in Figs. 1 and 2.

Referring to the figures more in detail, in Fig. 1 is shown a pair of oscillation generators 1—1 associated with the input circuits of space discharge amplifiers 2—2, respectively, which are adapted to raise the amplitude of the impressed oscillations to the necessary value to secure efficient modulation.

Sources 1—1 generate oscillations of the order of 4,500,000 cycles, but differing in frequency by a comparatively small amount such as 10,000 to 15,000 cycles. A frequency difference of this small order would be preferred in those cases where it is desired to utilize a minimum range of frequencies for the signal channel, but the operation of the invention is not dependent upon the use of a small frequency difference and equally good results may be obtained with frequencies spaced apart a million or more cycles per second.

Signaling currents in the circuit 3, which may be produced in response to variations in the microphone 4 or may be received over a telephone line, are impressed by means of transformer 5 upon the control electrodes of oppositely connected amplifiers 6, the con-

trol electrodes being thereby excited in opposite phases by the signal waves.

Modulation takes place in the output circuits of tubes 2 in accordance with the constant current method of modulation described in U. S. Patent to Heising No. 1,442,147 issued January 16, 1923. Reactance 7 connected in a common plate circuit of the several tubes serving as the means for maintaining the total space current constant. This particular type of modulation is shown merely by way of illustration and any other suitable type may be employed if desired.

Inasmuch as speech amplifiers 6 are connected in opposition with respect to the impressed signal currents, modulation of the carrier frequency oscillations in amplifiers 2 occurs in opposite phase, that is, as the space current tends to increase in one of the amplifiers 2, space current in the other amplifier tends to decrease.

Modulation high frequency oscillations in the output circuits of these amplifiers are impressed by means of transformers 8 upon the space discharge amplifier 9 which is adapted to raise the energy of the impressed current to that necessary for radiation.

Energy is transferred from the output circuit of amplifier 9 by means of transformers 11, to a transmission system herein shown as antenna 10. Since two carrier waves of different frequencies are to be radiated, antenna 10 is given two degrees of freedom by means of circuit 12 anti-resonant, approximately, to one of the transmission frequencies and tuned circuit 13 approximately anti-resonant to the other transmission frequency. It is not essential, however, to use this particular type of antenna as any type of antenna capable of radiating two different frequencies may be employed, or two separate antennae may be used. Again, with closely spaced carrier frequencies a simple antenna, possessing but one degree of freedom, may have sufficiently broad tuning to transmit both frequencies efficiently. In case two separate antennae are used care must be taken to avoid interaction due to the coupling provided by the capacity between the antennae.

Referring to Fig. 2, an untuned receiving antenna 20 is shown coupled to a detector 21 by means of a filter capable of accommodating both modulated waves within its transmission band.

Antenna 20 has been shown as untuned, or rather, as having fixed tuning, which should correspond to a frequency much higher than those of the received waves. However, other types of antenna may be substituted. For example, that described in connection with Fig. 1 may be used, the essential feature being that it receive all of the desired waves with equal sensitivity.

The particular filter network 22 is shown by way of illustration only. Various other

systems may be employed for coupling antenna 20 to detector 21 in such manner that two carrier waves having different frequencies may be transmitted to the detector with substantially equal attenuation. If two separate receiving antennae are used, simple tuned circuits could be employed to couple the antenna to the detector.

High frequency oscillations from source 23 are impressed upon detector 21 and are therein combined with the received oscillations to produce currents of intermediate frequencies which are passed through intermediate frequency amplifier 24 and impressed upon the input circuit of detectors 25 and 26 by means of transformers 27 and 28, the secondary windings of which are tuned by condensers 29 and 30.

Intermediate frequency amplifier 24 should transmit, with substantially equal gain, all of the intermediate frequency waves produced from the two received waves.

The intermediate frequency waves comprise two groups each including a carrier component and two side bands, the carrier components being substantially separated in frequency. The two groups of waves are separated by means of tuned transformers 27 and 28 and are impressed respectively upon detectors 25 and 26 which operate to produce the low frequency speech or signal currents. As a result of the method of modulation at the transmitting station, the signal currents produced in the output circuits of the detectors, are normally out of phase with each other. However, they are brought into phase with each other before being impressed upon signal responsive device 31. This is accomplished by means of oppositely connected audio-frequency transformers 32 and 33.

A two-channel system such as that described above effectively reduces the fading of the received signal. This effect may be still further increased by employing three or more channels which will decrease the probability of signals in all channels fading simultaneously to a minimum value of intensity.

The operation of this system to increase the efficiency of the transmitter will be better understood by referring to Fig. 3. Curve *a* represents the two equal carrier waves of frequencies f_1 and f_2 and their combined effect. The combined amplitude as shown by curve *a* varies between a maximum of twice the amplitude of either single carrier and zero. The effect of combining the signal wave represented by curve *b* with the two carriers in opposite sense is shown by curves *c* and *d*. As one carrier is increased in amplitude the other carrier is decreased in amplitude so that their sum remains substantially constant. Curve *e* shows the effect of combining curves *c* and *d*. The envelope of curve *e* is subject

to much smaller variations than the envelope of either separate curve *c* or *d*.

Referring to a particular case by way of further explanation, assume that amplifier 9 employs water-cooled power tubes rated a 10 k. w. maximum power. If used in an ordinary amplifier, these tubes would in practice be operated to deliver only $2\frac{1}{2}$ k. w. output when no signal is being transmitted, that is, $2\frac{1}{2}$ k. w. output of carrier frequency alone. The input voltage may be represented by frequency f_1 of curves *a*.

In the course of modulation, the input voltage may rise to twice the magnitude of the unmodulated carrier and decrease to zero, corresponding to output powers as high as 10 k. w. and as low as zero. The tube is therefore operated at its full rating only at recurrent intervals, and although it is possible to increase the average power by the use of greater input voltages, such a method is not feasible in a telephone system on account of the limits which can not be exceeded without introducing distortion. By combining the two modulated waves having out of phase signal modulations and impressing them together upon the amplifier, the recurrent variations of output power, corresponding to the period of the signal waves, are largely suppressed and the tube is operated continuously at substantially its full power rating. It is to be noted that this result is achieved, not by increasing the maximum instantaneous output of the tube, but by utilizing the power for one channel at the moments it is not required for the other. A single tube is thus enabled to do the work for which two tubes would ordinarily be required.

When three channels, or any other odd number of channels, are used for the same conversation, more of the frequencies must be modulated in one phase than are modulated in the other. This will result in a somewhat greater variation in the electro-motive force of the combined wave and consequently in a certain diminished gain in efficiency due to the combination. When the number of channels employed is even, the gain in efficiency will be substantially that obtained with two channels.

The system described not only provides means for reducing the effect of fading by employing a plurality of channels, but at the same time serves to increase the power supplied by a given space discharge amplifier tube.

Although the invention has been described in connection with one particular embodiment, it is not to be limited thereto but only in accordance with the scope of the following claims.

What is claimed is:

1. The method of signal transmission which comprises simultaneously modulating two carrier waves differing in frequency with

waves representing a common signal, combining the modulated waves and subsequently amplifying the combined waves, said modulating waves being oppositely phased whereby the amplitude of the combined waves does not exceed the maximum amplitude of one of the modulated waves alone.

2. The method of signal transmission which comprises simultaneously modulating two carrier waves differing in frequency with waves representing a common signal, combining the modulated waves and subsequently amplifying the combined waves, said modulated waves being phased with respect to each other to produce modulation in opposite senses whereby the amplitude of the combined waves does not exceed the maximum amplitude of one of the modulated waves alone.

3. The method of signal transmission which comprises simultaneously modulating two carrier waves of different frequencies and of substantially equal amplitudes with waves representing a common signal, combining the modulated waves and subsequently amplifying the combined waves, said modulated waves being oppositely phased whereby the amplitude of the combined waves does not exceed the maximum amplitude of either modulated wave alone.

4. The method of signal communication which comprises simultaneously modulating two carrier waves having different frequencies and substantially equal amplitudes with waves representing a common signal, combining the modulated waves and subsequently amplifying the combined waves, said modulating waves being oppositely phased whereby the amplitude of the combined waves does not exceed the amplitude of either modulated wave alone, transmitting the amplified waves and deriving a signal therefrom at a distant station.

5. The method of signal communication which comprises simultaneously modulating two carrier waves having different frequencies and substantially equal amplitudes with waves representing a common signal, combining the modulated waves and subsequently amplifying the combined waves, said modulated waves being oppositely phased whereby the amplitude of the combined waves does not exceed the amplitude of either modulated wave alone, transmitting the amplified waves, deriving a signal current from each modulated carrier at a distant station and combining the derived signal currents in additive relation.

6. In a high frequency communication system, two generators of carrier waves of different frequencies, a signal wave source, means operated by said source for modulating the waves from said generators simultaneously, an amplifier, means for combining and impressing upon said amplifier modu-

lated waves from said generators, said modulating means being adapted to modulate the carrier waves in opposite senses whereby the load on said amplifier due to the combined modulated waves does not exceed the load due to one of the modulated waves alone.

7. In a radio signaling system, sources of a plurality of carrier frequency waves, a source of signal frequency waves, means for modulating the waves from said carrier sources simultaneously in accordance with waves from said signal source, a power amplifier, means for impressing the modulated waves simultaneously upon said amplifier, said modulating means being adapted to modulate the carrier waves in opposite senses whereby the intensity of the resultant waves impressed on said amplifier does not exceed the maximum intensity of one of the modulated waves alone.

8. In a wave communication system, two generators simultaneously producing oscillations of different frequencies, a telephone transmitter, means operated by said transmitter for simultaneously modulating the oscillations produced by said generators, an amplifier, means for impressing the modulated oscillations simultaneously upon said amplifier, and means for transmitting the amplified oscillations, said modulating means being adapted to modulate the oscillations in opposite senses whereby the intensity of the combined oscillations in the amplifier does not exceed the intensity of one of the modulated oscillations alone.

In witness whereof, I hereunto subscribe my name this 18th day of October A. D., 1925.

RAYMOND A. HEISING.

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