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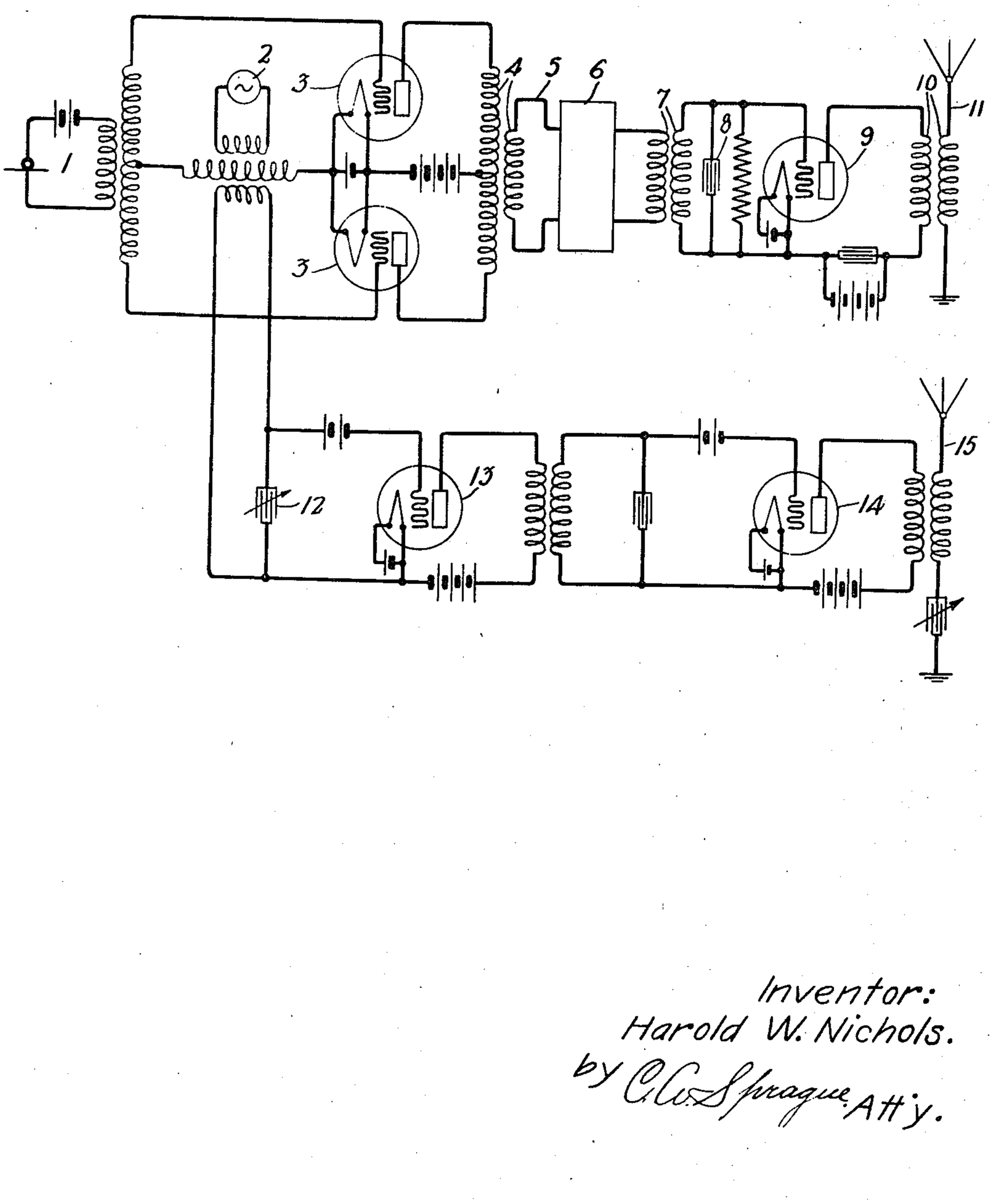
H. W. NICHOLS

CARRIER RADIO TELEPHONE SYSTEM

Filed Jan. 7, 1922



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UNITED STATES PATENT OFFICE.

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CARRIER RADIOTELEPHONE SYSTEM.

Application filed January 7, 1922. Serial No. 527,792.

To all whom it may concern:

Be it known that I, HAROLD W. NICHOLS, a citizen of the United States, residing at Maplewood, in the county of Essex, State of New Jersey, have invented certain new and useful Improvements in Carrier Radiotelephone Systems, of which the following is a full, clear, concise, and exact description.

This invention relates to a method of and means for transmitting signals, and more particularly to carrier telephone systems.

It has been proposed in signal transmission by modulated carrier waves to prevent the transmission of the unmodulated carrier wave component, while providing for the efficient transmission of the modulated carrier wave component, as described in the Journal of the A. I. E. E. Vol. XL. No. 4, page 314, April, 1921. It has also been proposed in a carrier system, to transmit a signal modulated wave i. e. the modulated carrier and two side band components and an unmodulated wave of frequency different from that of the carrier wave. At the receiving station the signal modulated and unmodulated waves are combined to produce a signal modulated wave of intermediate frequency which is then selected and again detected to give the signaling current.

The present invention has certain advantages over each of these systems in that it does not require a synchronously operating source of local oscillations at the receiving station, as in the first system, or the additional detector etc., as in the second system, to effect detection or demodulation of the incoming signal waves, whereby speech currents may be supplied to the receiver.

The present invention is directed to a system in which all the advantages inherent in the two systems briefly described above may be utilized and consequently a much greater economy of power and apparatus may be secured. According to this invention a carrier wave is modulated in accordance with speech frequency currents, the unmodulated carrier component and one side band are suppressed, the remaining side band of the pure modulated wave and a selected amount of unmodulated energy from the carrier source are transmitted independently and more efficiently to a distant cooperating receiving station where they are combined to produce the speech frequency current.

The primary object of this invention is to provide a carrier system which is both efficient and economical. Another object is to provide means whereby a pure modulated wave and energy of the fundamental carrier frequency may be transmitted from a signal station.

Other objects will be apparent to those skilled in the art from a perusal of the following description taken in connection with the attached drawing in which the single figure shows, by way of example, a radio transmitting system embodying the invention.

Referring to this figure there is shown a balanced modulating system of the type described in United States Patent No. 1,343,307, June 15, 1920, to J. R. Carson. A source of modulating current 1, comprising the ordinary microphone and associated current source, and a source of high frequency waves 2 are shown coupled by repeating coils to the input circuits of balanced modulating devices 3, the output circuits of which are differentially coupled by a transformer 4 to a circuit 5 including a filter 6. The modulating source 1 is oppositely coupled to the respective input circuits of the devices, while the high frequency or carrier wave source 2 is connected in the same direction to these input circuits. In operation as described in the above mentioned patent, the high frequency oscillations from source 2 impress equal voltage variations of the same phase upon the grids of the devices 3, thereby producing equal fluctuations of the same phase in their output circuits. The signal frequency current, on the other hand, being impressed in opposite phase on the grids of the devices, produces an unbalanced condition in the primary winding of the transformer 4 and hence modulated high frequency oscillations having an amplitude proportional to the signal frequency current are impressed upon the circuit 5. Thus unmodulated carrier oscillations are suppressed and oscillations of both the upper and lower side band frequencies are transferred to the circuit 5.

The filter 6 may be used to pass freely without appreciable attenuation, the waves of modulated side band frequencies and to interpose a large impedance to other frequencies and if desired, may be designed to suppress frequencies corresponding to one of the side bands. Let it be assumed that the carrier

frequency is 500,000 cycles, then for telephony a frequency band, of approximately 497,000 to 503,000 cycles will be transmitted through the transformer 7 to a circuit selective of these frequencies which may comprise the secondary winding of the transformer 7 and the shunting condenser 8. This tuned circuit is included in the input circuit of the amplifer 9, the output circuit of which is coupled by the transformer 10 to the antenna 11.

The repeating coil coupling the source 2 to the input circuits of the devices 3 is provided with a third winding shunted by a condenser 12 to constitute therewith a circuit which may be tuned to the carrier frequency. Oscillations of carrier frequency are selected by this circuit which is included in the input circuit of a high efficiency amplifier 13. The high frequency oscillations may be again amplified by a second amplifier 14 and radiated from an auxiliary antenna 15 tuned sharply to the carrier frequency. While this is the preferred arrangement, it is to be noted that the carrier frequency energy may be separately derived from the source 2, as described above, supplied to the primary of the transformer 10 and radiated from the same antenna 11 as the modulated wave. Obviously, energy of the modulated or unmodulated wave frequency, or both, may be impressed upon the antenna 11 or antennæ 11 and 15 by a direct connection. Where separate antennæ are used for transmission and a single side band component is radiated, the best results will be obtained when the antenna 11 is tuned to the mean frequency of the side band selected for transmission.

The best operation conditions will be obtained when both the unmodulated carrier component and one side band component are suppressed. When this is done, it is possible to radiate from the transmitting antenna 11 at least six and probably ten times as much useful modulated power as could be radiated from the antenna of a system in which the carrier wave is not suppressed. This is due to the fact that an amplifier, which is used to amplify variable amplitude currents, cannot operate at much more than 50% efficiency, provided all the peaks of the current are to be amplified without distortion. If the carrier is eliminated it is necessary to amplify at this comparatively low efficiency only the essential component of the modulated wave and not the carrier itself, which represents a large part of the energy to be handled. Again, if a high efficiency amplifier supplies the unmodulated carrier wave to the auxiliary antenna, since the amplitude of the wave is low and of uniform value, the amplifier may be operated at an efficiency of perhaps 85%. Therefore, the tube capacity required to produce and impress upon the ether the electrical wave components necessary to effect signal transmission and detection at the receiving station is much less than in the arrangements heretofore used. The antenna 11 should be tuned to the mid frequency of the side band transmitted, but broadly enough to take care of the band and the antenna 15 to the carrier frequency. These two frequencies will differ by about 1000 to 1500 cycles and if the tuning of the antenna 15 is sharp enough reactions of these antennæ upon one another may be avoided.

Since the tube installation normally employed in a transmission station is a large item in the first cost and operating charges, this invention, owing to its high power efficiency, reduces the apparatus employed and thereby increases the commercial efficiency very materially.

Although described as applied to radio telephone transmission it will be apparent that this invention is adapted for use with systems employing line conductors extending between the transmission and receiving stations for guiding the carrier waves and that it is in no way limited to telephony.

In the preceding description a particular mode of suppressing the unmodulated carrier frequency component, and specific details have been set forth with the object of clearly and completely disclosing the principles of the invention. However, since any means for producing a signal modulated wave and suppressing both the unmodulated carrier frequency component and one side band may be used, it is to be understood that this invention is not limited to the arrangement herein shown and described, but only by the scope of the appended claims.

What is claimed is:

1. A method of radio signal transmission which comprises producing a wave modulated in accordance with signal currents, suppressing the unmodulated carrier wave and one side band component, transmitting the other side band component, and separately impressing a wave of the carrier frequency upon the natural medium.

2. A method of radio telephone transmission which comprises producing a wave modulated in accordance with speech frequency signals, radiating one side band component, and separately radiating a wave of the carrier frequency.

3. A method of radio signal transmission which comprises modulating a carrier wave in accordance with signal currents, suppressing the unmodulated carrier and one side band component, amplifying and transmitting the other side band and separately amplifying and impressing a selected amount of the carrier wave upon the natural medium, whereby six to ten times as much use-

ful power may be transmitted to a co-operating receiving station for a given power output as in systems transmitting the carrier and both side band components.

4. A radio telephone system comprising a transmitting circuit, means for producing a wave modulated in accordance with speech frequency signals, means for suppressing the unmodulated carrier wave, means for impressing the modulated wave upon said transmission circuit, and separate means for impressing a wave of the carrier frequency upon the natural medium.

5. A radio telephone system comprising means for producing a wave modulated in accordance with speech frequency signals, means for suppressing the unmodulated carrier wave and one side band component, means for transmitting the other side band component, and separate means for impressing a wave of the carrier frequency upon the natural medium.

6. A radio telephone system comprising means for producing a wave modulated in accordance with speech frequency signals, means for suppressing the unmodulated carrier wave, means for suppressing one side band component, means for transmitting the other side band component, and means for separately impressing a wave of the carrier frequency upon the natural medium.

7. A radio telephone system comprising means for producing a wave modulated in accordance with speech frequency signals and suppressing unmodulated carrier wave, means for suppressing one side band component, means for transmitting the other side band component, and separate means for impressing a wave of the carrier frequency upon the natural medium.

8. A radio telephone system comprising a carrier wave source, means for producing a wave modulated in accordance with speech frequency signals, means for suppressing the unmodulated carrier wave, means for suppressing one side band component, means for transmitting the other side band component, means for separately impressing a wave of the carrier frequency upon the natural frequency, and means for supplying said last mentioned means from said carrier source.

9. A radio telephone transmitting system comprising a plurality of antennæ, means for supplying one side band component of a wave modulated in accordance with speech frequency signals to one antenna and means for supplying an unmodulated wave carrier frequency to the other antenna.

10. A radio telephone transmitting system comprising a plurality of antennæ, a balanced modulator for supplying side band components of a carrier wave modulated in accordance with speech, means associated with said modulator for suppressing one side band component, means for supplying the other side band component to one antenna and means for supplying an unmodulated wave of carrier frequency to the other antenna.

11. A radio telephone transmitting system comprising a plurality of antennæ, a carrier source, a balanced modulator for supplying side band components of a carrier wave modulator in accordance with speech, means associated with said modulator for suppressing one side band component, means for supplying the other side band component to one antenna and a common means for associating said source with the modulator and for supplying an unmodulated wave of carrier frequency to the other antenna.

12. A radio telephone transmitting system comprising means for modulating a carrier wave in accordance with speech frequency currents, means for selecting one side band, means for amplifying the selected side band, means for radiating said band, means for amplifying a selected amount of the carrier wave, means for separately radiating said amplified carrier, the power capacity of the amplifiers required for a given amount of useful power radiated being less than fifty per cent for a given power output than in systems transmitting the carrier and both side band components.

In witness whereof, I hereunto subscribe my name this 5th day of January, A. D. 1922.

HAROLD W. NICHOLS.