Mar. 27, 1923.

1,449,372.

H. D. ARNOLD.

SYSTEM OF TELEPHONY.

FILED DEC. 1, 1915.

Fig. 1.

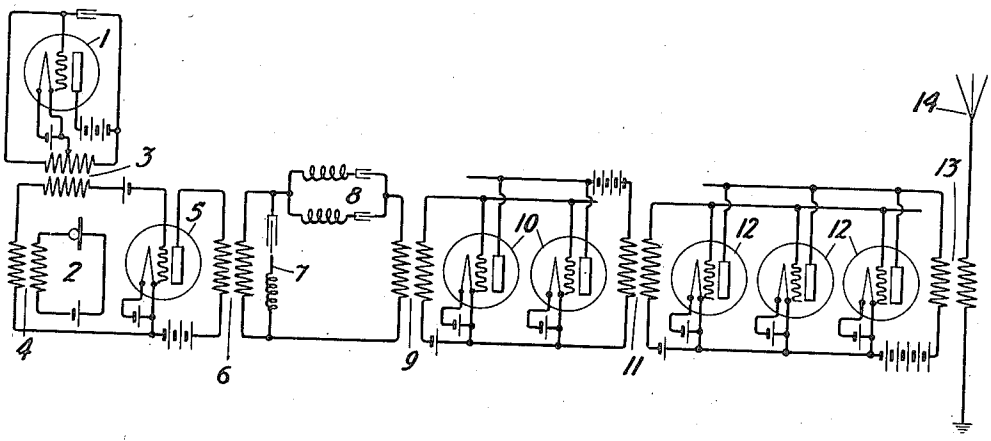
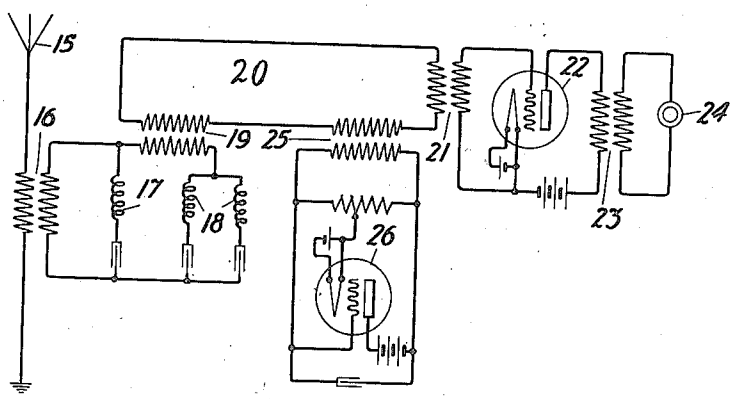


Fig. 2.



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UNITED STATES PATENT OFFICE.

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SYSTEM OF TELEPHONY.

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To all whom it may concern:

Be it known that I, HAROLD DE FOREST ARNOLD, a citizen of the United States, residing at East Orange, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Systems of Telephony, of which the following is a full, clear, concise, and exact description.

This invention relates to a method of, and apparatus for, signaling by means of modulated high frequency waves or currents.

More specifically its object is to increase the efficiency of telephonic communication by modulating a high frequency oscillation and eliminating from the antenna, or other sending circuit, constant amplitude oscillations of the carrier-wave frequency, which, in present practice, are impressed upon it. Further objects are to improve the quality of speech received and to make possible the secret transmission and reception of messages.

These objects are accomplished by providing an arrangement of circuits whereby current is suitably modulated and is supplied to the antenna only when the characteristics of the high frequency current to be impressed on the antenna are changing in accordance with the wave form of the signal to be transmitted, and by providing at the receiving station a small auxiliary generator which shall furnish a wave of the frequency of the unmodulated carrier wave.

Heretofore in high frequency carrier wave telephony it has been customary to employ a generator of unmodulated or carrier high frequency oscillations, which oscillations are modulated in amplitude in accordance with the low frequency signals to be sent, and are then radiated. At the receiving station, detecting devices are used to respond to low frequency modulations only.

Now in such a system, if the carrier wave is of frequency C, and the modulating signal wave of frequency S, the resultant modulated high frequency wave of a current of varying amplitude sent into the sending circuit can be resolved into three simple sine waves of frequencies C—S, C, C+S. These may be considered to be transmitted independently, and to recombine at the receiving station. This is the method which has heretofore been commonly followed, but in this invention, as hereinafter disclosed, steps are taken to prevent at all times the radiation of the unmodulated component with frequency C, and in certain cases to prevent, in addition, the radiation of one of the modulated components C—S (or C+S).

When the carrier wave is not being modulated, that is, when signals are not being transmitted, an unmodulated current or frequency C flows in the sending circuit, and the power represented by this current is wasted as heat or radiation. Further, when signals are being transmitted, only the first and third of the waves mentioned above contain the signal frequency, and hence in this case the wave of carrier frequency is of use only after it arrives at the receiving station and enters the detecting device. Since the power represented in the sending circuit by currents of frequency C may be several times that radiated in the other frequencies, the power so wasted in useless radiation is considerable, and requires large generator capacity.

Since this unmodulated wave of frequency C is required only at the receiving station, this invention proposes to eliminate it from the sending circuit, and to add, at the receiving station, a generator which shall supply a wave of this frequency to combine with the first and third of the waves above mentioned, or either separately when they arrive at the receiving circuit. Since only a very small part of the power radiated arrives at the receiving station, it is clear that the power output of this auxiliary generator need be but small (perhaps one millionth part of that of the sending generator), and there will result a decided gain in efficiency. I have found, for example in transmitting a note of audible frequency S, that in one case the unmodulated antenna current of frequency C was 25 amperes, and that of frequency C+S was but 7 amperes. By tuning out the frequency C, by means described later, this waste of power could be avoided. One simple method of tuning out the carrier frequency is to tune the sending circuit rather sharply to the frequency C+S (or C—S) where S is, for telephony, about 800 cycles per second. When this is done, transmission takes place almost entirely on but one frequency, C+S (or C—S), the other two waves being suppressed. By this adjustment, waves containing the signal frequen-

cies are transmitted with maximum amplitude; that is, the system is selective for audio frequencies of 800 cycles, as in the case of ordinary wire telephony.

My invention will be more completely described in connection with the drawings, in which Fig. 1 and Fig. 2 represent, respectively, a sending and a receiving station for radio telegraphy or telephony.

Referring to Fig. 1 which represents a form which may be taken by the transmitting station of this invention, 1 represents a high frequency generator of small power capacity, preferably an oscillating audion, such for example, as that described in the U. S. Patent No. 1,137,384 to E. H. Colpitts. By means of transformer 3 its oscillations are impressed upon the input circuit of a modulator 5. 2 represents a microphone circuit and 4 a transformer by means of which waves of signal frequency may also be impressed upon the input circuit of the modulator. These oscillations of signal frequency are preferably of somewhat greater amplitude than those impressed upon the modulator 5 by the generator 1. Under these circumstances the amplifying power of the device 5 is varied in accordance with the wave form of the telephonic currents in circuit 2, and there therefore appears in the output circuit of modulator 5 a modulated high frequency current. Transformer 6 serves to impress these modulated high frequency oscillations upon a system of tuned circuits next to be described, whose function is to prevent the passage of unmodulated currents of the carrier frequency to the sending antenna. This system of tuned circuits may also suppress one of the modulated components as described above.

This system of tuned circuits may be of any suitable form, and as shown here, consists of the resonant circuit 7 tuned to the carrier frequency and the pair of resonant circuits 8, one of which is tuned to a frequency slightly above the carrier frequency and the other to a frequency slightly below it, while the combination of these two circuits in parallel offers an infinite impedance to currents of the carrier frequency. When the transmitting circuit 2 is not in operation, the current in the output circuit of modulator 5 is of carrier frequency, and therefore no current appears in the primary of the transformer 9. The term "modulation" is intended herein to define the variations of the amplitude of oscillations of one frequency in accordance with a wave of lower frequency. In a broad sense, the term "modulation" is intended to specify a change in either the amplitude or the frequency or both, of periodic disturbances occurring in any medium, at a desired relatively low rate. In one aspect it is a change at a relatively low rate in the energy variations of a relatively high frequency wave.

The term "pure modulated wave" is used to define a modulated wave in which there is present no component having the wave form and frequency of the unmodulated high frequency oscillations and in which the modulation is complete, in the sense that the modulation is effective throughout the entire cyclic period of the modulating wave.

Now, as is well known, a high frequency wave, for example of frequency 50,000, when modulated by means of a current of, say 1000 cycles per second, is equivalent to three simple harmonic waves of frequencies 49,000, 50,000 and 51,000. The wave of carrier frequency of constant amplitude, namely 50,000, is not concerned directly in the transmission of speech, and it is this wave which it is proposed to eliminate in this invention. In this illustration, therefore, the tuned circuit 8 would have a small impedance to waves of frequency 49,000 and 51,000 and a practically infinite impedance to waves of frequency 50,000.

By means of transformer 9 waves of these two transmitting frequencies are impressed upon the input circuits of the amplifiers 10. It has been found in practice that a number of these, perhaps six or seven, arranged in parallel, is desirable. The common output circuit of these amplifiers is coupled by means of transformer 11 to the input circuits of a parallel arrangement of amplifiers 12, which are constructed to deliver from their output circuits a sufficient amount of power for radio operation. This power is delivered to the antenna 14 by means of transformer 13. There are therefore sent out into the ether two waves of frequencies slightly different from that of the unmodulated carrier wave which has been suppressed. In particular, since unmodulated waves of this frequency are no longer present in the antenna, the power represented by this current is not wasted.

Referring to Fig. 2, which represents a receiving system adapted for use in connection with the transmitting system of Fig. 1, 15 represents an antenna and 16 a transformer by means of which power is transferred from the antenna to a system of resonant circuits similar to that described in connection with Fig. 1. In this system, 17 is a resonant circuit tuned to the carrier frequency, and 18 a pair of circuits similar to 8 in Fig. 1. Transformer 19 communicates power from these tuned circuits to the circuit 20 and coupled to this circuit 20 through transformer 21 is a detecting element 22, whose output circuit supplies the receiving device 24 through the transformer 23. In order to introduce into the receiving system oscillations of the carrier frequency, the oscillation generator 26 is used,

which may be similar to the oscillation generator 1 of Fig. 1, and is coupled to circuit 20 by transformer 25. The power supplied by this oscillator 26 may obviously be very small compared to the power of the oscillations radiated at the sending station.

It will further be obvious that if the generator 26 is eliminated, there will remain only the type of circuit ordinarily used in receiving wireless messages, and if the unmodulated component is suppressed at the transmitting station, the quality will be very poor, and if, in addition, one of the modulated components is suppressed, the signals will not be interpreted and the system may be used for secret transmission of messages.

Although this invention has been described in connection with a telephone system, it will be obvious to those skilled in the art that its use is not so limited, since, as is well known, telegraphy and other methods of signaling involving modulating a high frequency current are fundamentally the same in principle as carrier current telephony. It is also obvious that this invention is applicable to systems employing a conductive transmission circuit, as well as to radio systems.

What is claimed is:

1. The method of signalling which comprises modulating a carrier frequency wave in accordance with a signal and subsequently suppressing the carrier frequency component of the resultant wave.

2. The combination of a transmitting station comprising a source of high frequency waves, a source of low frequency waves, a thermionic modulator upon whose input circuit are impressed the waves generated by said sources to produce a wave having an unmodulated component and side frequency components comprising respectively a wave of the frequency generated by said high frequency source and the combination frequencies of the waves from said high and low frequency sources, a tuned circuit whereby the unmodulated component is suppressed, a system of amplifiers, a sending antenna connected to said system of amplifiers, with a receiving station comprising an antenna, a tuned circuit, an auxiliary source of waves of frequency equal to that of the waves generated by said first mentioned source, and a detecting device acted upon by said received waves and by said auxiliary waves.

3. The combination with means for producing a wave, of means for modulating said wave in accordance with a signal, means for transmitting said wave, and means for suppressing the unmodulated component of said wave comprising a circuit interposed between said modulating means and said transmitting means and tuned to the frequency of said component.

4. The combination with means for producing a wave, of means for modulating said wave in accordance with a signal, and means for suppressing the unmodulated component of said wave comprising a branched circuit, one branch of which offers high impedance and another branch of which offers low impedance to said component.

5. The combination with means for producing a wave, of means for modulating said wave in accordance with a signal, and means for suppressing the unmodulated component of said wave comprising a branched circuit, one branch of which is tuned to said unmodulated component and another branch of which is tuned to two frequencies, one higher and one lower than that of said component.

6. Signal transmitting means comprising a source of oscillations, means to modulate said oscillations in accordance with signals to produce a wave having an unmodulated component and side frequency components comprising respectively the oscillations of the frequency generated by said source and the combination frequencies of said oscillations and the signal waves, means to filter out the unmodulated component, and means to amplify the modulated oscillations passed by said filtering means.

7. The method of signaling, which consists in transmitting high frequency carrier waves, whose amplitude is directly proportional to a low frequency signal wave, and combining therewith another wave.

8. The method of signaling, which consists in transmitting high frequency carrier waves whose amplitude is directly proportional to a low frequency signal wave, and combining therewith another wave of carrier frequency and constant amplitude.

9. The method of signaling, which consists in transmitting, to the exclusion of other waves, a high frequency carrier wave whose amplitude is directly proportional to a low frequency signal wave, and combining therewith another wave of carrier frequency and constant amplitude.

10. In a signaling system, means for producing a carrier wave component and a signal representing side band component and means for separating said components including a combination of electrical elements which comprise a series-resonant path for alternating current impulses of a frequency corresponding to one of said components and a parallel-resonant path for alternating current impulses of a frequency corresponding to the other of said components.

11. In a signaling system, means for producing a carrier wave component and a signal representing side band component and means for separating said components including a combination of condensive and inductive elements arranged to form a series-resonant path for alternating currents of a

frequency corresponding to one of said components and a parallel-resonant path for alternating currents of a frequency corresponding to the other of said components.

12. In combination, a source of waves comprising an unmodulated carrier component and signal representing side band components and means providing high impedance for said unmodulated component and low impedance for said side band components comprising a branched circuit, one branch of which is resonant to one side band and the other branch of which is resonant to the other side band.

13. In combination, a source of waves comprising an unmodulated carrier component and signal representing side band components and means providing high impedance for said unmodulated component and low impedance for said side band components comprising a branched circuit, one branch of which is resonant to one side band and the other branch of which is resonant to the other side band, said branches comprising a loop which is resonant to said unmodulated component.

14. In combination, a source of complex waves including components of desired frequencies and a component of an undesired frequency and means for separating said components, comprising a group of reactive elements arranged to form parallel paths for the passage of electrical energy and comprising a series-resonant path for each of said desired frequencies and a parallel-resonant path for said undesired frequency.

15. In combination, a source of complex waves having a component of a desired frequency and a component having an undesired frequency and a circuit for passing the component of the said desired frequency and for suppressing the component of said undesired frequency, comprising a loop circuit tuned to resonance with said undesired frequency and comprising two branch circuits, one of which is resonant at said desired frequency and the other of which is resonant at a frequency spaced from the undesired frequency an interval equal to that between said desired and undesired frequency and in the opposite direction.

16. In a signaling system, means for producing a high frequency wave, means for modulating said wave in accordance with a signal to give an unmodulated component and side frequency components, said means comprising a space discharge modulator, and means in addition to the modulating means for suppressing the unmodulated component of the modulated wave.

17. The method which consists in generating high frequency oscillations modulated in accordance with a signal wave to produce a wave having an unmodulated component and side frequency components, attenuating the unmodulated components of the current resulting from modulation, and amplifying the resultant current.

18. The method which consists in generating undamped high frequency oscillations modulated in accordance with a signal wave to produce a wave having an unmodulated component and side frequency components, filtering out the unmodulated component thereof, and amplifying and transmitting the resultant wave.

19. The combination in series energy relation of a means for modulating high frequency oscillations in accordance with a signal wave to produce a wave having an unmodulated component and side frequency components, a filter for eliminating the unmodulated component from the modulator output, and means for amplifying the resultant current.

20. The combination in series energy relation of a means for producing a high frequency signal modulated wave, a filter, and an amplifier, said filter comprising a shunt circuit resonant to one component of the modulated wave and a series loop also resonant to a component of the modulated wave.

In witness whereof, I hereunto subscribe my name this 26th day of November, A. D., 1915.

HAROLD D. ARNOLD.