

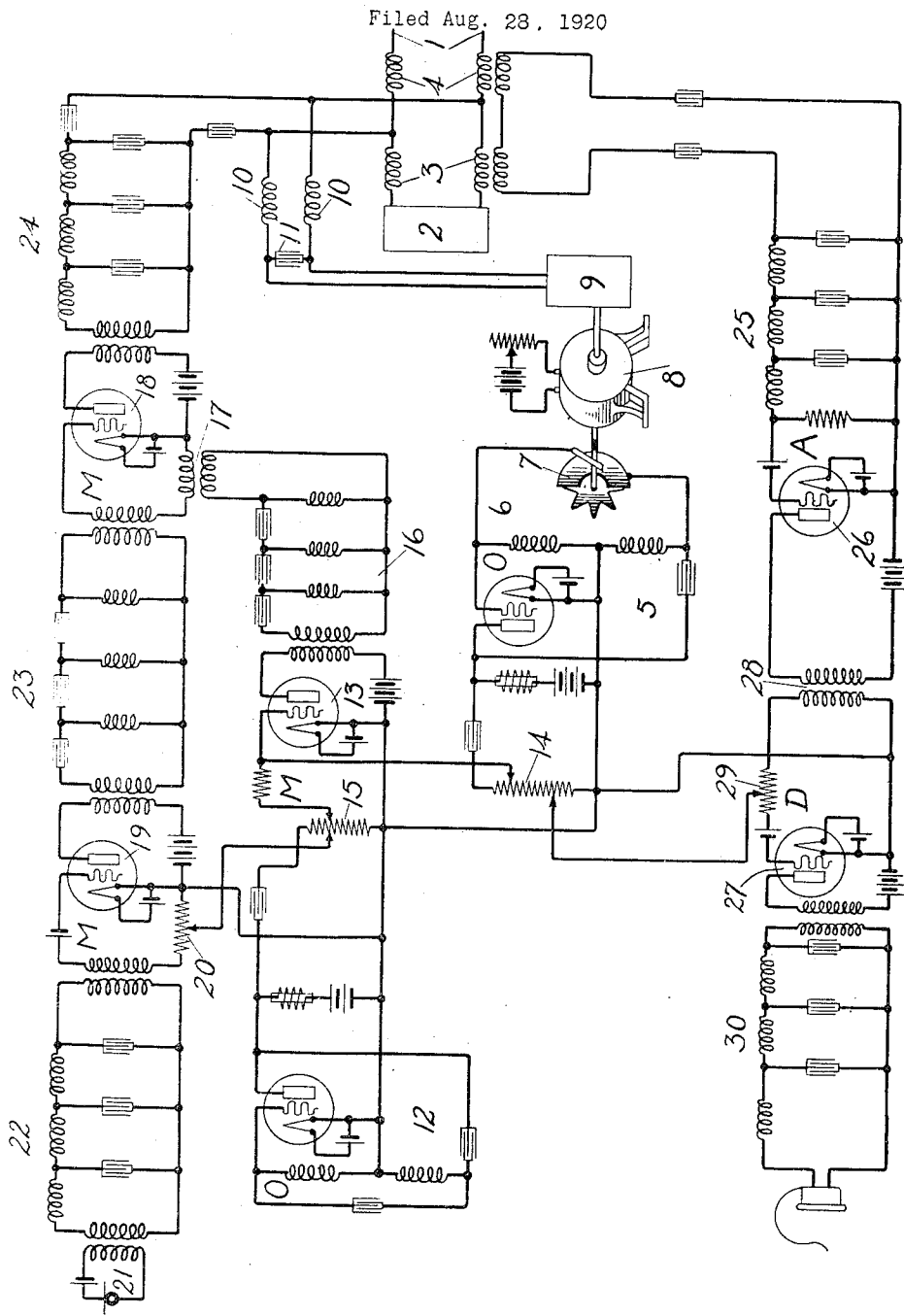
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R. V. L. HARTLEY

SECRET SIGNALING

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UNITED STATES PATENT OFFICE.

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SECRET SIGNALING.

Application filed August 28, 1920. Serial No. 406,700.

To all whom it may concern:

Be it known that I, RALPH V. L. HARTLEY, a citizen of the United States, residing at East Orange, in the county of Essex, State of New Jersey, have invented certain new and useful Improvements in Secret Signaling, of which the following is a full, clear, concise, and exact description.

The present invention relates to the control of waves employed in signaling or in the transmission of energy for other purposes.

More specifically, the invention relates to the control of carrier waves and to the modulation of such waves in accordance with signals, and to transmission and reception of such waves. The invention is especially concerned in the modulation and control of carrier waves used in secret signaling, particularly in secret telephony.

In an application of Burton W. Kendall, Serial No. 409,073, filed September 9, 1920, a system of secret telephony is disclosed in which a high frequency wave of varying frequency is used for the carrier. In that system, which, like the one presently to be described, is applicable to use on wire line transmission systems, the unmodulated carrier wave component is suppressed, the currents of the original signaling frequencies are suppressed, and one side band only of the modulated wave is allowed to reach the line. The complete suppression of the undesired frequency components is accomplished by plural modulation and by filters, and does not depend upon any particular type of modulator. To receive the wave of such a system, it is necessary to supply to the receiving circuit a wave having the characteristics of the carrier wave and unless the frequency and the scheme of varying the frequency of the carrier wave are known, it is impossible to receive the message transmitted.

The preferred manner of controlling the waves for transmission in that system is briefly as follows:

Currents of essential voice frequencies s (or other signaling frequencies) modulate a wave of fixed frequency p , giving, as one component, current of frequencies $p+s$. A wave of continuously varying frequency, indicated by $p+v+d$ where v is a fixed frequency and d varies in any predetermined

manner between zero and a chosen fixed limit, is modulated by the component current of frequency $p+s$ giving as a result a modulated wave having a lower side frequency component of frequency $v+d-s$, and the other components of which are of higher frequency than p . If, as in the case of voice currents, s comprises a band of frequencies, there will be a band of frequencies $v+d-s$. Since p can be made arbitrarily large, it is a simple matter to control the frequencies so that the side band $v+d-s$ is much lower than frequency p and can therefore be transmitted by a low pass filter, that is, a filter freely passing currents lower than an assigned limit, to the exclusion of the components of all the other frequencies present, which are suppressed by the filter.

The frequency $v+d$ may be within the limits of audibility although this is not essential. In such a case a side band of frequency $v+d-s$ will be audible. A particular component of this side band if produced by a low frequency speech current will be of comparatively high frequency; if by a high frequency speech current, of comparatively low frequency. The currents of the resulting side band, although of audio frequency, will have an entirely different frequency arrangement from the original speech currents and will be unintelligible. It is therefore possible to transmit unintelligible message currents and the system may in this manner be given an additional degree of secrecy. The carrier frequency used in such a system is $v+d$ and the frequency p does not appear in the final modulation product that is transmitted. The wave of frequency p serves only in the intermediate step of the modulation in order to step up the effective frequency of the speech to the value $p+s$ to give final modulation components differing widely in frequency and easily capable of separation by filters. The carrier frequency is therefore derived as the difference between two waves of frequencies p and $p+v+d$ respectively.

If the waves p and $p+v+d$ are derived from independent sources, the difference wave will not in practice be exactly $v+d$ where d indicates the predetermined variable component of the carrier frequency, but

will be $v+d$ plus or minus a correction term to take care of the difference in the two p -values, since it is impossible in practice to run two high frequency generators independently so as either to maintain their frequencies absolutely the same or to have their frequency variations exactly alike. If the frequency p of the wave, which is introduced merely to take part in the production of the wave to be transmitted, but is not itself transmitted, is always maintained equal to the component p in the wave $p+v+d$ which is to be neutralized in the second stage of the modulation then the carrier wave will be exactly $v+d$. According to the present invention, the waves of frequencies p and $v+d$ are separately generated and in the modulating process at the transmitter they are added together and thereafter the same wave of frequency p is subtracted again so that the resulting frequency $v+d$ is maintained independent of variations in the frequency p .

The nature and objects of the invention will appear more fully from the following description of a specific embodiment of the invention as illustrated in the schematic circuit diagram of the accompanying drawing.

This circuit diagram represents the apparatus at one station on the line 1 and includes the necessary elements for both transmitting and receiving secret telephone messages. The line 1 is balanced by the net 2 and the coils 3 and 4 in the customary manner to permit two-way communication over the line without interference between the transmitting and receiving circuits. At the station illustrated, the transmitting apparatus is shown in the upper portion of the figure and the receiving apparatus in the lower portion.

The wave which serves as a carrier for the speech currents is generated by the oscillator 5 which may be of any suitable type and is shown as an oscillating thermionic tube. The frequency of the oscillator is controlled by the resonant circuit 6, the tuning of which is preferably cyclically varied by means of the variable condenser 7 which has a movable plate or plates continuously driven by the constant speed-motor 8. Any other means of producing a wave of varying frequency $v+d$ may be used. Although this wave has been previously described as preferably of audible frequency, it may be of very high or inaudible frequency.

It is assumed that a similar oscillator similarly controlled to give a frequency $v+d$ is located at the distant receiving station, since in the present system such a wave must be used at the receiver to render the transmitted message intelligible. The motor-driven condenser at that station (not shown) is preferably kept in synchronism

and in phase with the condenser at the station shown by means of correcting impulses sent over the line 1 from contact-making mechanism indicated in a general way at 9. The particular synchronizing system to be used forms no part of the present invention and it is to be understood that any known method may be used whereby impulses sent out periodically from a contact-making means 9 operate to introduce phase corrections in the motor-driven condenser at the distant station. It is also evident that these impulses give no clue to the carrier frequency used or to the scheme of varying it, since any desired gear ratio may be used between the motor and the condenser, or the condenser plates can have any desired number and shape of scallops, and the number of impulses sent out per revolution by the motor can be varied to suit conditions. The inductances 10 and condenser 11 serve as a low frequency filter to permit the synchronizing impulses to pass to the line but to keep the signaling frequency currents out of the commutator circuit.

The wave of high frequency p which is used in the preparation of the wave for transmission is generated by the thermionic oscillator 12 which may be of any suitable type for producing a continuous high frequency wave. The output waves of frequencies p and $v+d$ from the oscillators 12 and 5 respectively, are impressed on the input circuit of the modulator 13. Potentiometer resistance 14 and 15 enable the amplitude of the respective waves applied to the modulator to be adjusted. By the well-known action of the modulator 13, currents of combination frequencies involving the impressed frequencies are produced including an upper side band of frequencies $p+v+d$ and other components of frequencies lower than this. The high pass filter 16 is designed to permit the passage of the frequencies comprised in the band $p+v+d$ but to suppress all the other frequency components from the output of the modulator. The wave of frequency $p+v+d$ is then applied through the coupling 17 to the input circuit of the modulator 18.

The oscillator 12 in addition to supplying the wave of frequency p to the modulator 13 also applies a wave of this frequency to the modulator 19. The amplitude of the wave so applied may be controlled by the potentiometers 15 and 20. This wave is modulated in the tube 19 by the signal waves such as speech waves originating in the microphone circuit 21. A low-pass filter 22 suppresses currents of the unessential high frequencies of the voice and permits the passage of all frequency currents up to a predetermined upper limit. As a result of this modulation, an upper side band of frequencies $p+s$ will be obtained in addition to

frequencies p , $p-s$, and components of the double frequencies of both p and s and possibly still other frequencies. The filter 23 which is a high pass filter is designed to transmit the upper side band $p+s$ but to suppress all lower frequency components. Currents comprising the band $p+s$ are therefore supplied to the input circuit of the modulator 18 along with the wave $p+v+d$ applied through the coupling 17 as described. Among the most important frequency components resulting from the action of modulator 18 are the upper band of frequency $p+s+p+v+d$, the lower band of frequency $p+v+d-(p+s)=v+d-s$, and the unmodified component of frequency $p+s$. Since p can be made arbitrarily high, it is evident that the lowest frequency in the band $p+s$ can be made as far as desired above the highest frequency in the band, $v+d-s$ and this band $v+d-s$ may therefore be completely separated by the low pass filter 24 and transmitted to the line.

Since the wave of frequency, p supplied to the modulator 19 always has the same frequency as the wave supplied to the modulator 13 to produce the frequency $p+v+d$, it is evident that the difference frequency $v+d$ will be at all times unaffected by fluctuations in the frequency of the oscillator 12.

It is assumed that the wave received at the station shown over the line 1 has a frequency $v+d-s$, although if desired, a different frequency could be used for transmitting in this direction. The wave to be received is selected by the filter 25, is acted upon by the amplifier 26, and is impressed on the detector 27 through the coupling 28. To receive the signal component s of this wave, it is necessary to supply to the detector 27 a wave of frequency $v+d$. This wave of frequency $v+d$ is derived from the oscillator 5 in the same manner as is the wave used in transmitting, and its strength may be adjusted by the potentiometers 14 and 29. The tube 26, in addition to amplifying the received wave, prevents the passage of the wave $v+d$ from the oscillator 5 to the line by way of the input circuit of the detector 27 and coupling 28. The two waves impressed on the detector combine to reproduce the signaling wave s which is selectively transmitted by the low pass filter 30 and gives an audible signal in the telephone receiver 31.

It will be seen from the foregoing description that by means of the present invention the wave of high frequency p can be introduced and later can be completely neutralized so as not to produce disturbing frequencies in the final output. This introduction of the high frequency wave and its elimination after it is used, is especially applicable to the system of secret telephony of the type disclosed but may also have appli-

cation in other kinds of systems as well. The invention therefore is not to be construed as limited to the particular system which has been illustrated and described but its scope is defined in the appended claims.

What is claimed is:

1. The method of modulating a carrier wave by a signal which comprises supplying another wave, modulating said other wave by said signal, modulating said other wave by the carrier wave, and modulating one of the components resulting from the modulation of said other wave by the carrier wave by a component resulting from the modulation of said other wave by said signal, to produce a carrier wave modulated by said signal.

2. The method of producing a carrier wave modulated by a signal which comprises supplying a wave of different frequency from said carrier wave, modulating said wave of different frequency by said signal, separately modulating said wave of different frequency by said carrier wave, and combining in a modulator a component resulting from one such modulating step with a component of the other modulating step to produce a carrier wave modulated by said signal.

3. In a modulating system employing two stages of modulation, the method of supplying to one stage a high frequency wave and to the other stage another high frequency wave having a frequency equal to the sum of the carrier frequency to be used and the frequency of said first-mentioned wave, which method comprises producing a wave of the carrier frequency and a wave of said first-mentioned high frequency, supplying said wave of first-mentioned high frequency to one stage, separately modulating said wave of first-mentioned high frequency by said carrier wave to produce their sum frequency, and selecting and transmitting to said second stage the wave of said sum frequency.

4. In modulated wave signal transmission, the method of producing a pure-modulated wave of a definite carrier frequency which comprises modulating a different high-frequency wave by the signal to be transmitted, modulating said high frequency wave by the carrier wave, selecting the sum-frequency components produced by each such modulation, modulating one of said sum-frequency components by the other to produce a signal-modulated carrier wave, and selecting for transmission a portion of the signal-modulated wave components comprising one side band only of said signal modulated wave.

5. In a transmission system means for producing a carrier wave, means for producing another wave of a different frequency, means for modulating said wave of

- different frequency by signals to be transmitted and for modulating said wave of different frequency by said carrier wave to produce their combination frequencies, and means for selecting and for modulating certain of said combination frequencies by the signal-modulated wave of said different frequency to produce a signal-modulated carrier wave.
6. In a transmission system, a generator of a high frequency wave, a generator of a wave of a different frequency, a modulator for controlling one of said waves by the other to produce their combination frequencies, means for selecting certain of said combination frequencies, two modulators in tandem for signal transmission, and means for supplying to one of said modulators, a portion of the output wave of one of said generators and for supplying to the other of said modulators the selected combination frequencies.
7. A secret telephone transmission system comprising a modulator and circuits for supplying to said modulator currents of essential voice frequencies and a wave of constant frequency to be modulated thereby, a circuit for selecting and transmitting the upper side band resulting from such modulation and for suppressing all lower frequency components, a source of waves of varying high frequency, a second modulator and circuits for impressing on said modulator the currents of frequencies comprising said upper side band and a wave of varying high frequency produced by the combination of said wave of constant high frequency with the wave from said source of varying high frequency, and a circuit for selecting and transmitting currents of the frequencies comprising the lower side band from second modulator and for suppressing transmission of unmodulated currents of both said constant frequency and said varying high frequency.
8. The method of modulating a carrier wave by a modulating wave, which comprises increasing the frequency of the modulating wave and increasing the frequency of the carrier wave by equal amounts before modulation, whereby the frequency separation of the resulting side bands is increased and the effective transmission carrier frequency is unchanged.
9. The method of modulating a carrier wave by a modulating wave, which comprises combining a third wave with said modulating wave and said carrier wave to increase the frequency of both said carrier and said modulating wave by the frequency of said third wave, and modulating the increased frequency carrier wave by the increased frequency modulating wave.
10. A modulating system comprising a source of carrier waves, a source of modulating waves, means for increasing the frequency of said carrier waves by a definite amount, means for increasing the frequency of said modulating waves by the same amount, and means for modulating said increased frequency carrier wave by said increased frequency modulating wave.
11. In combination, means for producing a modulating wave, means for producing a carrier wave, means for producing a third wave, means for combining said third wave with said carrier wave to produce a carrier wave of increased frequency, means for combining said third wave with said modulating wave to produce a modulating wave of increased frequency, and means for modulating said increased frequency carrier wave by said increased frequency modulating wave.
12. The method of producing and transmitting a signal-modulated carrier wave while completely suppressing transmission of both the signaling waves and the carrier waves themselves, comprising separately combining the signaling wave and the carrier wave with a third wave to obtain modulated waves of respectively higher frequency than the signaling wave or the carrier wave, transmitting these modulated waves while suppressing transmission of the signaling and carrier frequencies by filtering and modulating these two separately produced modulated waves by each other to produce a signal-modulated carrier wave for transmission.
13. In combination two modulators, a common source of sustained waves applied to both of said modulators, a source of signaling waves applied to one of said modulators, a source of carrier waves applied to the other, filters connected to the output of said modulators for selectively passing certain of the modulated components only and a third modulator supplied through said filters.
14. In a transmission circuit three separate modulating circuits, a source of waves applied in common to two of said modulating circuits and an individual source of waves applied to each of said two modulating circuits, said third modulating circuit being supplied with two waves through said two modulating circuits.
15. In a transmitting circuit a source of signaling waves, a source of carrier waves and a modulator for effecting modulation of said carrier waves by said signaling waves, a modulator interposed between said first modulator and said source of signaling waves, another modulator interposed between said first modulator and said source of carrier waves and a source of waves connected in common to said two interposed modulators.
16. In combination two modulators sup-

plied by sustained waves of the same frequency and each by a different modulating wave, and a third modulator supplied by output waves from said two modulators.

5 17. Means for modulating a carrier wave by signaling waves of nearly the same frequency as said carrier wave while completely suppressing transmission of unmodified components of both the carrier and the signaling waves, comprising a modulator, high
10 pass filters connected between said modulator and the source of signaling and carrier waves, the characteristics of said filters being such that they suppress transmission
15 of currents of the order of frequency of said signaling waves and of said carrier waves, frequency-changing circuits for elevating the frequency of both said signaling and said carrier waves by the same amount
20 so that the waves of elevated frequency pass through said filters and into said first mentioned modulator and a filter connected to the output of said first mentioned modulator for transmitting only the lower side band of
25 the modulated waves.

18. In combination a source of signaling waves and a source of carrier waves, means to increase the frequency of each of said waves by the same amount, filters for selectively transmitting the increased frequency waves, said filters suppressing transmission of currents of the frequencies of said sources, a modulator supplied by the increased frequency waves from said filters
30 and a low pass filter connected to said modulator for transmitting only the difference

frequency between the frequencies of the applied waves.

19. In secret signaling the method of modulating a carrier wave by speech waves while preventing the passage of either the carrier wave or the speech waves themselves to the line through the modulating apparatus, which method comprises first modulating a sustained wave by speech and
40 separately modulating a wave of the same frequency by the carrier wave, selectively transmitting the upper side band components of the waves so modulated by filtering while suppressing transmission of all lower
45 frequency waves including the original speech and carrier waves, modulating one of said upper side band waves by the other and selectively transmitting the lower side band resulting from said last mentioned
50 modulation.

20. In a signaling system a source of signaling waves of frequency s , other wave sources of frequencies p and $v+d$ respectively, means to produce by modulation
50 waves of frequencies $p+s$ and $p+v+d$ respectively, filtering circuits for separating these modulated waves practically pure from waves of lower frequencies, and further modulating and filtering means for producing from these modulated waves a wave of
55 frequency $v+d-s$ to the substantial exclusion of waves of all other frequencies.

In witness whereof, I hereunto subscribe my name this 13th day of August A. D.,
60 1920.

RALPH V. L. HARTLEY.