June 16, 1925. 1,542,567

R. C. MATHES

SECRET SIGNALING

Filed June 30, 1923

Fig. 1.

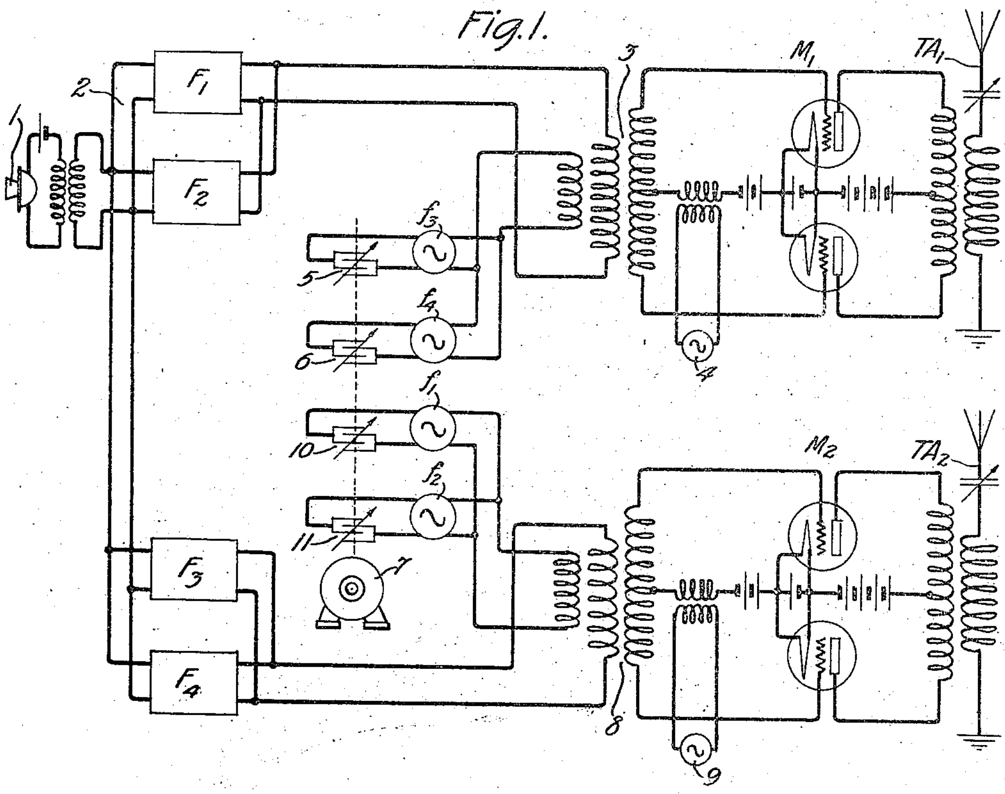
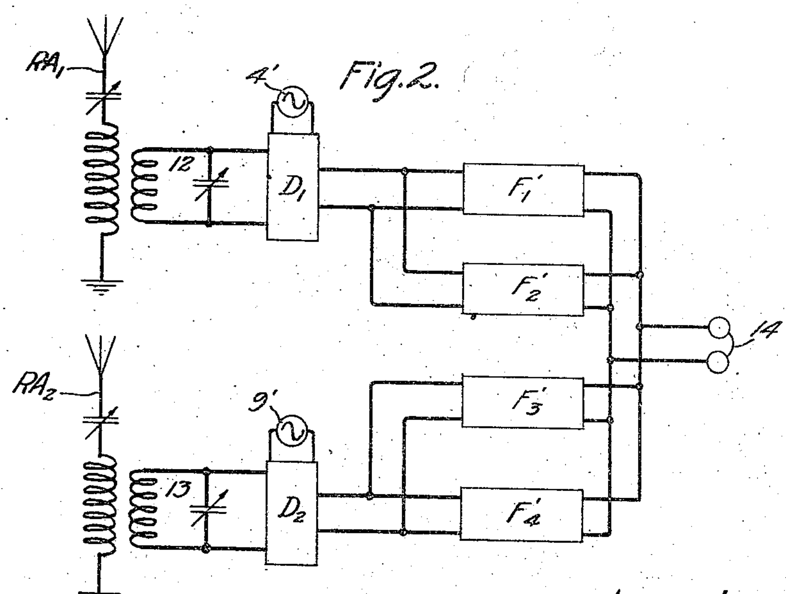


Fig. 2.



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UNITED STATES PATENT OFFICE.

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SECRET SIGNALING.

Application filed June 30, 1923. Serial No. 648,649.

To all whom it may concern:

Be it known that I, ROBERT C. MATHES, a citizen of the United States, residing at New York city, in the county of Bronx and State of New York, 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 secret transmission of waves for any desired purpose, such as signaling.

The invention is particularly applicable to the transmission and reception, with secrecy, of waves such as signals and the like comprised of a considerable band of frequencies, as in the case of speech.

An object of the invention is to obtain a high degree of secrecy with comparatively simple terminal apparatus and by such transformations of the signal or other waves as will preserve a high degree of quality in the reproduced signals or waves at the receiver.

In the specific form of embodiment to be described herein, the speech waves to be secretly transmitted are subdivided into relatively narrow sub-bands of frequency components. A plurality of these sub-bands non-adjacent to one another in frequency are transmitted over one transmission path or channel, and other sub-bands are sent over a different channel. For example, the sub-bands transmitted over the first channel may comprise every alternate sub-band taken in the order of ascending frequencies, and the remaining sub-bands may be sent over a different channel. The frequency intervals between the successive sub-bands transmitted over the same channel may be occupied by noise components.

At the receiver arranged in accordance with the invention, the sub-bands received over each path are separated from the noise currents by suitable selective means and the sets of sub-bands transmitted over the different channels are combined in the receiver.

To an outsider who does not have access to all of the channels over which component parts of the same message are transmitted, or who does not know the number, width, and arrangement of the various sub-bands, or has not the necessary filters to separate the speech components from the noise components, it is impossible to receive any intelligible speech waves from the transmitted waves.

The various features and objects of the invent[illegible] will be more fully apparent from the following detailed description of the system embodying the invention illustrated in the accompanying drawing. In the drawing, Fig. 1 is a schematic circuit representation of a transmitting station, and Fig. 2 is a similar representation of a receiving station adapted to cooperate with the station of Fig. 1 in carrying on communications with secrecy.

The speech currents developed in the circuit 2 as a result of speaking against the transmitter 1 are applied to the series of subdividing or analyzing filters F_1, F_2, F_3, F_4. Each of these filters is a band transmission filter of the type disclosed in the patent to Campbell, No. 1,227,113 of May 22, 1917. These filters are for the purpose of subdividing the normal speech frequency band into sub-bands of relatively narrow frequency range, each of which sub-bands by itself is incapable of reproducing understandable speech.

The two sub-bands selectively transmitted by the respective filters F_1 and F_2 are non-adjacent in frequency, and are preferably spaced apart in frequency by an interval equal to the width of the band transmitted by the filter F_3. Similarly, the filter F_4 transmits the next higher adjacent band to that transmitted by the filter F_2, it being assumed that the filter F_2 transmits higher frequencies than the filter F_1.

With the arrangement of the four filters as shown in this figure, therefore, it will be seen that the lowermost sub-band of the speech impulse is transmitted by the filter F_1. The next higher sub-band beginning substantially at the upper limit of the first band is transmitted by the filter F_3. Similarly, the next higher band beginning substantially at the upper limit of the frequency range of the filter F_3 is transmitted by the filter F_2 and the highest of the four sub-bands is transmitted by the filter F_4. If more than four filters are used, the sub-bands may be of correspondingly narrower frequency range, and, as in the case shown in the drawing, the analyzing filters will be grouped into a plurality of sets, the filters of each set transmitting sub-bands which are non-adjacent in frequency.

The sub-bands transmitted by the filters F_1 and F_2 are applied to the modulator M_1 through the input transformer 3. This modulator is supplied also by a carrier wave from the source 4 so that the applied sub-bands modulate the carrier wave, and produce for transmission a modulated wave having two side bands, as is well known in the art.

Sources f^3 and f^4 of continuous waves are also arranged to be applied to the modulator M_1, simultaneously with the sub-bands from the filters F_1 and F_2. These wave sources are preferably vacuum tube oscillators of the type shown in the patent to Hartley, No. 1,356,763, October 26, 1920, the tuning condensers 5 and 6 of which are arranged to have their movable plates continuously driven by the motor 7 so that the frequency of each generator varies cyclically between two fixed limits. The limits between which the frequency of the oscillator f^3 varies are of the same order of frequency as the frequency limits of the band transmitted by the filter F_3. Similarly, the frequency of the oscillator f^4 varies over a range equivalent to the transmission range of the filter F_4. The rate of variation of the frequency of these wave sources may be sufficiently high so that if they were applied to a telephone receiver they would appear as noise currents having a band of frequencies of the width equivalent to the frequency separation of the limiting frequencies between which they are varied.

As a result of applying to the modulator M_1 both the sub-bands from the filters F_1, F_2 and the noise currents from the oscillators f^3 and f^4, the carrier wave 4 is modulated by a band of frequencies of normal speech frequency width. It is preferred to use a balanced modulator of the type indicated so that the unmodulated carrier component is suppressed at the transmitting station. Also by sharply tuning the transmitting antenna TA_1 to one of the two side-bands resulting from the modulation, the components that are transmitted can be restricted to those comprising a single one of the two side bands. Instead of using the type of modulator shown, a modulator circuit of the type disclosed in the patent to Osborne, No. 1,361,488, December 7, 1920, may be employed for the purpose of restricting the transmitted components to those comprised in the single side band. By so restricting the transmitted components, the actual amount of energy transmitted is only about one-sixth as great as would be the case if both side bands and the unmodulated carrier component were transmitted.

The sub-bands transmitted by the filters F_3 and F_4 are applied to the modulator M_2 through the transformer 8. This modulator is also supplied with carrier waves from the source 9 and with noise currents from the oscillators f^1 and f^2. These oscillators have their tuning condensers 10 and 11, respectively, continuously varied by the motor 7 so that they furnish noise currents composed of bands of frequency components substantially equal in width to the transmission ranges of the filters F_1 and F_2, respectively.

The carrier frequency produced by the source 9 is different from that produced by the source 4. As a result of the application to the modulator M_2 of the various waves as described, a modulated wave is produced having a side band width equal to the width of normal speech and the unmodulated carrier component and one of the two side bands are suppressed as described in connection with the modulator M_1. The remaining single side band is transmitted from the transmitting antenna TA_2. Carrier wave sources 4 and 9 may each be of the type disclosed in the Hartley patent, supra.

To an unauthorized person who intercepts either or both of the modulated waves from transmitting antenna TA_1 and transmitting antenna TA_2, the received currents will appear only as noise currents incapable of reproducing speech. This is true since the components of any single sub-band represent only unintelligible components and it is impossible to superpose the sub-bands transmitted over both channels in such a way as to build up the speech range, since the noise components transmitted from the sources f^1 to f^4 cover practically the entire speech range and may readily be made of such amplitude as to completely drown out the speech components.

The speech transmitted by the system of Fig. 1 is received in accordance with the invention by means of an arrangement such as is shown in Fig. 2. In this figure the receiving antenna RA_1 is tuned to receive the modulated wave transmitted from the antenna TA_1 and the receiving antenna RA_2 is tuned to receive the other of the two transmitted waves.

The frequency interval between the two transmitted waves should be large enough to permit of good selectivity between the waves at the receiving station. Instead of relying on receiving circuits tuned to the transmitted wave frequency, a beat oscillator may be used to step down the received frequencies and the selection may be carried out at a frequency lower than the transmitted wave frequency. In either case a practically complete separation will be made between the waves transmitted over one of the high frequency paths or channels and those transmitted over the other channel, so that the waves from one of the channels are applied exclusively through the tuned circuit 12 to the detecting circuit D_1, and the waves from the other channel are applied from the tuned circuit 13 to the detecting circuit D_2. These detectors are supplied with waves of the respective carrier frequency from the respective wave sources 4′ and 9′ which may be oscillators of the type shown in Hartley's patent, supra. As a result of the detecting action of D_1 waves are produced equivalent to those applied to the modulator M_1 at the transmitting station by the filters F_1 and F_2 and by the noise sources f^3 and f^4. The filters F_1' and F_2' connected to the output of detector D_1, may be identical respectively with the filters F_1 and F_2, so that corresponding sub-bands of the speech currents are selected from the detector D_1 exclusive of the noise components, which are dissipated in the filtering circuits.

The filters F_3' and F_4' may be identical respectively to the filters F_3 and F_4 at the transmitting station, so that the corresponding sub-bands resulting from detection of the waves received at D_2 are selectively transmitted to the exclusion of the noise currents produced by the noise sources f^1 and f^2. The output sides of all of the filters F_1' to F_4' are connected in common to the receiver indicated at 14. The sub-bands selected from the original speech message and separately transmitted are thus recombined and applied to the receiver 14 so that the speech is reproduced in understandable form.

While the invention has been described as applied to a radio transmitting and receiving system, it is to be understood that the invention is equally applicable to other types of transmission, such as transmission over wires either by the carrier current method or as direct transmission at the speech frequency level. It will be obvious to supply amplification at various points in the system.

What is claimed is:—

1. The method of secret transmission of a message wave having a band of frequencies, comprising dividing said band of frequencies into sub-bands of frequencies, transmitting over one of a plurality of separate channels a plurality of the sub-bands so divided that are non-adjacent one another in frequency and sending over another channel other subdivided frequency components of said message band including frequency components intermediate the non-adjacent sub-bands transmitted over the first mentioned channel.

2. The method of secret transmission of waves having a band of frequencies, comprising dividing the waves into sub-bands of frequencies, transmitting every alternate sub-band, taken in the order of their frequencies, over one transmission channel and transmitting the other sub-bands over a different transmission channel.

3. The method of secret transmission of waves having a band of frequencies, comprising dividing the waves into sub-bands of frequencies, transmitting a plurality of non-adjacent sub-bands over each of a plurality of channels, and supplying to each channel noise currents of frequencies corresponding to the frequency intervals between the sub-bands transmitted on the respective channels.

4. The method of secret transmission of speech, comprising dividing the speech waves into sub-bands of frequencies, transmitting over one path a plurality of sub-bands non-adjacent in frequency, and transmitting over another path a plurality of sub-bands including frequency components intermediate, in frequency, those transmitted over the first-mentioned path.

5. The method of secret transmission of speech comprising dividing the speech waves into sub-bands of frequencies, transmitting over each of a plurality of paths a plurality of sub-bands non-adjacent in frequency, and supplying to each path noise currents having frequencies corresponding to the frequency intervals between the sub-bands transmitted over the respective path.

6. The method of secret transmission of speech comprising dividing the speech waves into sub-bands of frequencies, modulating a carrier wave of given frequency with the alternate sub-bands, taken in the order of frequency of the sub-bands, and modulating a carrier wave of a different frequency with the other sub-bands.

7. The method of secret transmission of speech comprising dividing the speech waves into sub-bands of frequencies, modulating a carrier wave of a given frequency by a plurality of sub-bands non-adjacent in frequency and by noise currents of frequencies corresponding to the frequency intervals between said non-adjacent sub-bands, and modulating a carrier wave of another frequency by sub-bands intermediate, in frequency, those used to modulate the first-mentioned carrier wave and by noise currents of frequencies corresponding to the frequency intervals between the respective sub-bands used to modulate the second-mentioned carrier wave.

8. The method of receiving the waves secretly transmitted by the method defined in claim 1 comprising receiving the sub-bands separately transmitted over each of the channels and applying them in common to a receiving circuit.

9. The method of receiving the waves secretly transmitted by the method defined in claim 3 comprising separating the sub-bands transmitted over each channel from the noise currents by filtering, and applying

the sub-bands from the several channels in common to a receiving circuit.

10. The method of receiving speech waves secretly transmitted by the method defined in claim 6, comprising separately detecting said carrier waves to yield sub-bands of the frequencies used at the transmitter to modulate the respective carrier waves, selecting the sub-bands and applying them in common to a receiving circuit.

11. In a telephone system, a source of speech currents, a plurality of transmission channels, and a plurality of frequency selective elements, each selective of a different frequency connected between each of the transmission channels and said source of speech currents.

In witness whereof, I hereunto subscribe my name this 26th day of June A. D., 1923.

ROBERT C. MATHES.