June 27, 1933. J. H. HAMMOND, JR 1,915,785

TRANSMISSION AND RECEPTION OF RADIANT ENERGY

Filed March 2, 1929

Fig. 1

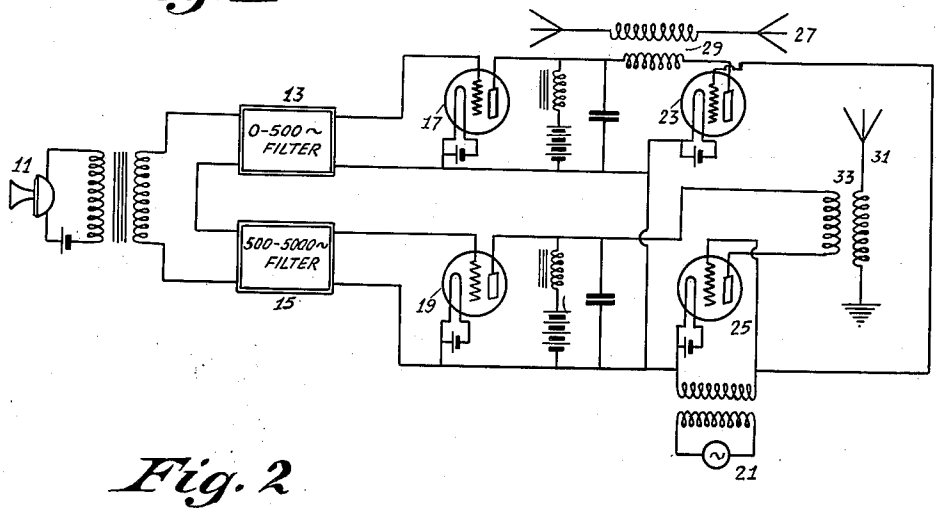


Fig. 2

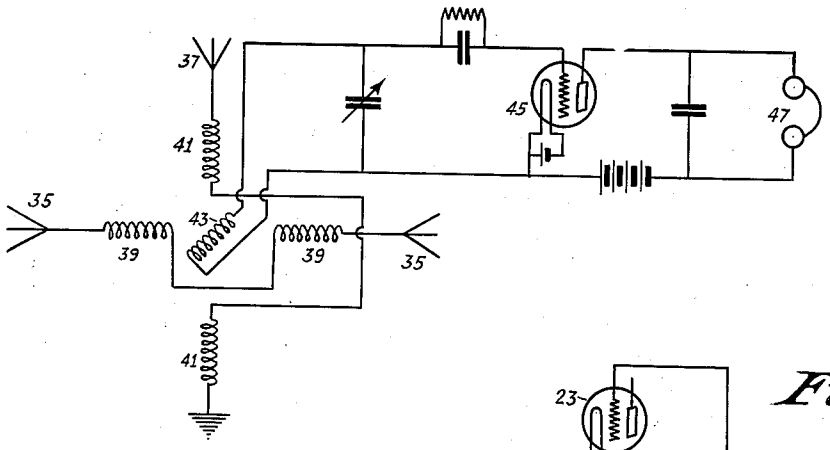


Fig. 3

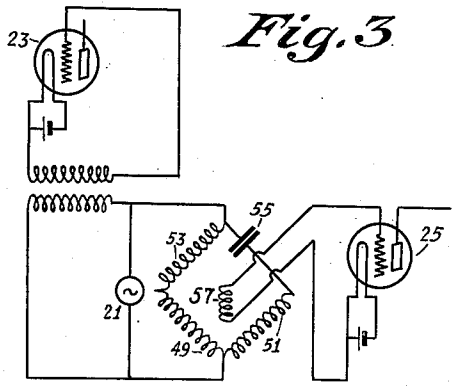


Fig. 4

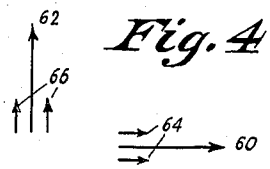
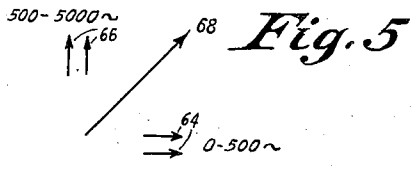


Fig. 5



Inventor
JOHN HAYS HAMMOND JR.

By his Attorney Ira J. Adams

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UNITED STATES PATENT OFFICE

JOHN HAYS HAMMOND, JR., OF GLOUCESTER, MASSACHUSETTS

TRANSMISSION AND RECEPTION OF RADIANT ENERGY

Application filed March 2, 1929. Serial No. 343,902.

The radiation of electromagnetic waves from a given antenna has a polarized effect according to the direction of the length of the antenna. Thus an antenna having a vertical length will transmit vertically polarized waves, and an antenna having a horizontal length will transmit waves which are horizontally polarized. A receiving antenna is similarly best adapted to receive waves which have been polarized in the direction of their length. In other words, the transmission from the vertical and horizontal antennæ will be such that it is best adapted to be received by a similar antenna depending, of course, upon the distance and the character of the intervening territory. This effect is termed polarization.

At a distance, the effect of polarization of ether waves is very pronounced and the transmission from a vertical antenna, for instance, cannot be received at all on a horizontal antenna, and vice versa.

The object of this invention is to transmit secret radio messages.

It is another object of the present invention to utilize the polarization characteristics of the transmission from horizontal and vertical antennæ to transmit messages which are difficult of reception by unauthorized receivers.

It is a further object of this invention to produce a transmission which it will be difficult, if not impossible, to receive on the ordinary type of receiver.

Further objects of this invention will become apparent upon consideration of the following specification taken in connection with the accompanying drawing.

A transmitter constructed in accordance with my invention would consist of a double radio phone transmitter, one part of which would emit radio frequency energy modulated by the 0–500 cycle portion of the message to be transmitted, and the other part of which would emit the high frequency energy modulated by the 500–5000 cycle portion of the message to be transmitted. The carrier frequency for both parts of the transmitter may be supplied by the same source and the audio frequency to be emitted may be supplied by the same microphone. However, the audio frequency would be supplied through appropriate filters and one of the resulting audio frequency bands would be used to modulate the transmission as applied to one of the modulators and supplied to an antenna having a substantially horizontal extent, and the other of said bands would be used to modulate the carrier frequency as applied to the other of said modulators and used to supply an antenna of substantial vertical extent. In reception, the horizontally and vertically polarized waves are received and combined so as to reconstruct the original audio frequency, in such a manner that it will be free from distortion.

It is obvious that if a receiver is equipped to receive a wave polarized in one direction more effectively than a wave polarized in the other direction, the audio frequency detected from such reception would be distorted and unintelligible.

Having thus briefly described my invention, attention is invited to the accompanying drawing wherein:

Fig. 1 represents a transmitter for carrying out the object of my invention.

Fig. 2 is a receiver for cooperation with the transmitter shown in Fig. 1.

Fig. 3 is a modification of the means for supplying the carrier frequency to the transmitter shown in Fig. 1.

Figs. 4 and 5 are diagrams showing the relationship between the carrier frequency and side band frequencies emitted by the two antennæ as well as the resultant ether wave of polarization.

Attention is now more particularly invited to Fig. 1 which shows a mircrophone 11, the output of which is adapted to be supplied through the filters 13 and 15 to the modulators 17 and 19 respectively. The carrier frequency to be emitted is supplied by means of the oscillator 21 which may be of any suitable type. The high frequency is impressed upon the grids of the amplifier tubes 23 and 25 which are arranged in parallel.

The output of the modulator 17 serves to modulate the radio frequency output of the modulated radio frequency amplifier 23 in

any usual and well known manner, such as that shown for purposes of illustration. The modulated output is adapted to be supplied to the horizontal antenna system through the coupling transformer 29.

Similarly, the output of the modulator device 19 is adapted to modulate the radio frequency amplifier 25 and this modulated output of tube 25 serves to supply the vertical antenna system with a modulated high frequency through the coupling transformer 33.

The two filters may be of the band pass type and one, for instance 13, may be adapted to pass only frequencies of from 0–500 cycles, in which case the output of the antenna 27 would be modulated only at these frequencies. Similarly, the filter 15 might be adapted to pass frequencies of from 500–5000 cycles or higher if desired, and the output of the antenna 37 would be modulated at these frequencies only.

Referring now more particularly to Fig. 2, there is shown a receiver having a horizontal antenna system 35 and a vertical system 37. The coupling coils 39 are included in the horizontal antenna system and the coupling coils 41 are included in the vertical antenna system. For supplying the energy picked up by said antennæ to the receiver at the proper ratio, there is provided a rotating pick-up coil 43, which may variably be coupled to the coupling coils 39 and 41 as desired. The receiver may be of the usual type comprising a detector 45 adapted to be supplied by a tuned circuit, including the coupling coil 43. The output of the circuit may comprise any audio frequency utilization system, shown in this instance as the telephone receiver 47. It is understood, of course, that any desired degree of amplification may be used at either radio, audio, or intermediate frequency.

Fig. 3 shows the amplifier tubes 23 and 25 which are the same as the amplifier tubes 23 and 25 of Fig. 1. The high frequency source 21 may be of any suitable type. Means are provided for coupling the radio frequency source to the two devices 23 and 25 in any desired phase relationships. The said coupling as illustrated, shows the usual transformer coupling as applied to the tube 23. The coupling to the tube 25 is through a vario coupler 57 which may be variably coupled to the coils 49 and 51 of the phase shifter which comprises, in addition to said coupling coils, the inductance 53 in series with the coupling coil 49, and the capacity 55 in series with the coupling coil 51.

Either the coupling coils shown may be of resistance wire or appropriate resistances (not shown) may be provided in series with them. By the proper proportioning of the inductances, resistances and capacities of these circuits, it is obvious that the phase of the current existing in the coil 49 may be caused to have a lag of 45° with respect to the voltage, whereas the current in the coil 51 may be made to have a lead of 45° with respect thereto.

By this means the currents in the two coils differ by 90 electrical degrees, the same as in a two phase induction type motor. Coil 57 may be rotated to pick up voltage from either or both of the coils, in such a manner that the total voltage induced in 57 is independent of its angular setting in a manner similar to a coil suspended in the rotating field of a two phase induction motor. But the phase of the voltage with respect to the supply phase depends upon the angular setting, and by properly positioning the angular setting of coil 57, the voltage induced therein may be made to have any desired phase relationship relative to that of any other voltage, thereby giving full latitude of the phase relationships of the voltages on the grids of tubes 23 and 25 and of the currents in the two antennæ.

Fig. 4 shows at 60 a line which represents the carrier frequency transmitted by the horizontal antenna 27 of Fig. 1. The side bands transmitted by the horizontal antenna are represented as the short lines 64. 62 represents the carrier frequency as transmitted by the vertical antenna 31 of Fig. 1, and the short lines 66 represent the side bands transmitted by the vertical antenna. The side bands of the horizontally polarized transmission will be those produced by the modulation of the carrier frequency produced by the generator 21 by the audio frequencies which pass through the filter 13. They will therefore be the carrier frequency plus 0–500 and the carrier frequency minus 0–500. Similarly, the side bands of the vertically polarized transmission will be those produced by the modulation of the carrier frequency produced at 21 by the audio frequencies passing through the filter 15 and will consequently comprise the carrier frequency plus 500–5000 cycles and the carrier frequency minus 500–5000 cycles.

Fig. 5 shows at 68 the resultant polarization of the carrier frequency transmitted by the antennæ 27 and 31 of Fig. 1. The side bands, however, are shown as remaining polarized vertically and horizontally respectively, as in Fig. 4. It is evident that whereas the carrier frequency exists in the transmission on both the horizontal and vertical antennæ, the side band frequencies existing in the vertical antenna are entirely missing in the horizontal antenna, and vice versa, and therefore the polarization of the side band frequencies remains the same as the direction of extent of the antennæ emitting said side band. Having thus described my invention, I will briefly describe its operation.

The transmission of the horizontal an-

tenna 27 will comprise the carrier frequency modulated only by the lower voice frequencies and therefore the carrier frequency plus the side bands produced by said modulation. Whenever any high notes come through, they will be filtered out by the filter 13, and therefore there will be no high audio frequency components in the transmission of the horizontal antenna. Similarly, the transmission of the vertical antenna will comprise the carrier frequency modulated in accordance with only the high voice frequencies. Therefore this transmission will comprise the carrier frequency plus the side bands produced by the high voice frequency modulations and the low frequency side bands will be missing from the transmission of the vertical antenna.

Thus a receiving station of the ordinary type, which will undoubtedly receive waves polarized in one direction better than those polarized in another, will receive the transmission of my invention in such a manner that after detection the audio frequencies will be distorted. This is in view of the fact that the reception of the vertically polarized and horizontally polarized waves will be out of balance and the high audio frequency components produced after detection will be all out of proportion to the low audio frequency components and therefore there will be distortion of the audio frequencies. This distortion will prevent the signals received from being intelligible.

However, the receiver shown in Fig. 2 may be so adjusted that the proper relationship between the audio frequency components derived from the energy received from the horizontal and vertical antennæ may be established. The audio frequency produced by the demodulation in the detector 45 is properly proportioned to establish the normal ratio between the high and low voice frequency components by varying the coupling of the coil 43 relative to the coils 39 and 41.

In case the device of Fig. 3 is utilized, a different type of effect from that of Fig. 1 is produced only when the phases of the two carrier currents in the antennæ are made to differ by other than 0 or 180 electrical degrees. These special values of phase also may be produced by Fig. 1 either as shown, or by reversal of sense of one antenna coupling coil, either 29 or 33, and they result in a definite tilt of the carrier wave to the right or to the left of the line of propagation. This is shown for example in Fig. 5, in which line 68 represents the direction of the ether strain due to the carrier. But with any other phase relationship as, for example, a difference of 90 electrical degrees produced by a proper setting of the rotor 57, of Fig. 3, the strain due to the carrier will be elliptical or circular, being at all directions in succession in the radio cycle. The ether strains due to the side bands however are plane polarized, being horizontal for the 0—500 range, and vertical for the 500–5000 range. In this case a simple type receiver as in Fig. 2 cannot pick up the radiations with a single coil 43 in such a manner as to produce good audio quality.

In this instance, it will be necessary to provide a receiver comprising a detector for each of the horizontally and vertically polarized waves. The combining of the audio frequencies would take place after detection and the strength of the audio frequency currents would be adjusted in any desired manner to give the proper relation to the high and low frequency components produced by the two detectors.

In another possible modification, the phase of the high frequency supplied to one antenna could be continuously varied with respect to the phase of the current supplied to the antenna so that the tilt of the resultant carrier wave would vary. This could be done by rotating the rotor of the vario coupler 57 at any desired frequency, as, say, 500 cycles. This would be the equivalent of shifting the carrier wave supplied to this antenna, and if the rotation were in such direction as to increase the frequency of the carrier thus affected, the carrier frequency supplied to this antenna would be 500 cycles greater than that supplied to the other. This would cause an overlapping spectrum and it would be impossible for anyone to receive a message clearly unless the vertical and horizontal waves were separately received by polarized reception as indicated in Fig. 2, using, however, a separate detector circuit for the horizontally and vertically polarized waves. A complete circuit for doing this would be the same as that shown in Fig. 2 of the application of John Hays Hammond, Jr., for System of transmission of radiant energy, Serial No. 343,903 filed concurrently herewith, except that instead of producing a rotating field the output of the two detectors would be combined into a single utilization circuit.

Anyone trying to tune to both waves on the ordinary receiver would get a 500 cycle beat note just as if receiving two broadcasting stations separated by 500 cycles.

Having thus described my invention, it is to be understood that many modifications may be used and that I am therefore not to be limited by the specific form shown and described for the purpose of illustration only, but by the scope of my invention as set forth in the appended claims.

Having now described my invention, what I claim is:

1. The method of radio transmission which comprises modulating a carrier frequency current by a portion of the audio frequency band it is desired to transmit and transmitting said modulated carrier frequency current in the form of a polarized wave, modu-

lating a second carrier frequency current by another portion of the audio frequency band it is desired to transmit, and transmitting said second mentioned modulated carrier frequency current in the form of a polarized wave the angle of polarization of which differs from the first mentioned polarization, receiving the two polarized transmissions and combining the received energy to reproduce the original audio frequency.

2. The method of radio transmission which comprises transmitting the carrier frequency energy in the form of horizontally and vertically polarized waves, modulating the horizontal and vertical components of said transmission by different portions of the audio frequency band which it is desired to transmit, independently receiving the horizontally and vertically polarized transmission, and combining said received energy to reproduce the original audio frequency.

3. The method of radio transmission which comprises modulating a carrier frequency by a portion of the audio frequency band it is desired to transmit, transmitting said modulated carrier frequency in the form of a polarized wave, modulating a second carrier frequency by another portion of the audio frequency band, and transmitting said second mentioned modulated carrier frequency in the form of a polarized wave, the angle of polarization of which differs from the first mentioned polarization.

4. The method of radio transmission which comprises transmitting a carrier frequency in the form of horizontally and vertically polarized waves, and modulating the horizontal and vertical components of said transmission by different portions of the audio frequency band it is desired to transmit.

5. Apparatus for the transmission and reception of radiant energy which comprises, means for supplying an audio frequency, filter means for filtering out a portion of said audio frequency, means for producing a radio frequency, means for amplifying the portion of said audio frequency which is not filtered out, means for modulating said radio frequency by said amplified audio frequency, means for transmitting said modulated radio frequency in a horizontally polarized manner comprising a horizontal antenna, means for filtering out another portion of said audio frequency, means for amplifying the audio frequency retained by said last mentioned filter means, means for modulating said radio frequency by said last mentioned amplified audio frequency, means for transmitting said last mentioned modulated carrier frequency in a vertically polarized manner comprising a vertical antenna, means for receiving said horizontally polarized radiation, means for receiving said vertically polarized radiation, means for properly proportioning the amount of energy received by said receiving means with respect to the audio frequency components thereof, means for combining and detecting the received radiations to reproduce the originally supplied audio frequency.

6. Means for the transmission and reception of radiant energy which comprises, filter means for dividing the audio frequency to be transmitted into two audio frequency bands, means for independently modulating the carrier frequency by each of said bands, and means for transmitting the two independently modulated carrier frequencies in a horizontally and vertically polarized manner respectively, means for independently receiving each of said polarized transmissions, means for properly proportioning the amount of each of said receptions with respect to the audio frequency components thereof, and means for reproducing the original audio frequency.

7. Means for the transmission and reception of radiant energy which includes a transmitter comprising a source of high frequency, a source of low frequency, filters for dividing the audio frequency supplied by the source of audio frequency into two audio frequency bands, thermionic means for independently modulating said carrier frequency by each of said audio frequency bands, means for regulating the phase relationship of the high frequency energy supplied to each of said thermionic modulator means, means for transmitting the modulated high frequency energy from said thermionic modulator means, comprising, a horizontal antenna, and a vertical antenna, and a receiver which includes a horizontal antenna, a vertical antenna, means for regulating the energy received from each of said antennæ, and detector means for reproducing the original audio frequency from said received energy.

8. Means for the transmission and reception of radiant energy which comprises a transmitter including a source of high frequency energy, a source of the low frequency energy it is desired to transmit, means for dividing the low frequency energy into two low frequency bands, means for independently modulating the high frequency energy by each of said bands, means for varying the phase of the high frequency supplied to each of said modulating means, means for transmitting the energy supplied by each of said modulating means including means for polarizing the transmission of said means in different directions respectively, and a receiver which includes means for independently receiving the two polarized transmissions, means for reproducing the low frequency components of said transmissions and means for properly adjusting the phase relationship of said transmissions to properly proportion the

low frequency components with respect to each other whereby to reproduce the original low frequency.

9. Means for the transmission and reception of radiant energy which comprises a transmitter including, means for transmitting a modulated carrier frequency in a vertically and horizontally polarized manner so that one band of the low frequency components it is desired to transmit shall appear only in the horizontally polarized transmission and another band of the low frequency components it is desired to transmit shall appear in the vertically polarized transmission, and means for varying the phase of the carrier frequency of one of said polarized transmissions with respect to the other, and a receiver including means for independently receiving the horizontally and vertically polarized transmissions and reproducing the original low frequency.

10. Apparatus for the transmission of radiant energy which comprises, means for supplying an audio frequency, filter means for filtering out a portion of said audio frequency, means for producing a radio frequency, means for amplifying the portion of said audio frequency which is not filtered out, means for modulating said radio frequency by said amplified audio frequency, means comprising a horizontal antenna for transmitting said modulated radio frequency in a horizontally polarized manner, means for filtering out another portion of said audio frequency, means for amplifying the audio frequency retained by said last mentioned filter means, means for modulating said radio frequency by said last mentioned amplified audio frequency, and means comprising a vertical antenna for transmitting said last mentioned modulated carrier frequency in a vertically polarized manner.

11. Means for the transmission of radiant energy which comprises, filter means for dividing the audio frequency to be transmitted into two audio frequency bands, means for independently modulating the carrier frequency by each of said bands, and means for transmitting the two independently modulated carrier frequencies in a horizontally and a vertically polarized manner respectively.

12. Means for the transmission of radiant energy which includes a transmitter comprising a source of high frequency, a source of audio frequency, filters for dividing the audio frequency supplied by said source of audio frequency into two audio frequency bands, a thermionic means for independently modulating said carrier frequency by each of said audio frequency bands, means for regulating the phase relationship of the high frequency energy supplied to each of said thermionic modulator means, and means comprising a horizontal antenna and a vertical antenna for transmitting the modulated high frequency energy.

13. Means for the transmission of radiant energy which comprises a transmitter including a source of high frequency energy, a source of the low frequency energy it is desired to transmit, means for dividing the low frequency energy into two low frequency bands, means for independently modulating the high frequency energy by each of said bands, means for varying the phase of the high frequency supplied to each of said modulating means, means for transmitting the energy supplied by each of said modulating means including means for polarizing the transmission of said means in different directions respectively.

14. Means for the transmission of radiant energy which comprises a transmitter including, means for transmitting a modulated carrier frequency both in a vertically and horizontally polarized manner so that one band of the low frequency components it is desired to transmit shall appear only in the horizontally polarized transmission and another band of the low frequency components it is desired to transmit shall appear in the vertically polarized transmission and means for varying the phase of the carrier frequency of one of the said polarized transmissions with respect to the other.

15. The method of radio communication which comprises producing a carrier frequency current, producing signal currents of varying frequencies, modulating said carrier frequency current with said signal currents and transmitting the resulting energy with different transmission characteristics dependent upon the frequencies of the signal currents.

16. The method of radio communication which comprises, producing a carrier frequency current, producing signal currents of varying frequencies, modulating a portion of said carrier frequency current with a portion of the signal currents, modulating another portion of the carrier frequency current with another portion of said signal currents and differently polarizing each portion of the resulting modulated carrier frequency during transmission thereof.

17. The method of radio communication which comprises, producing a carrier frequency current, producing signal currents of varying audio frequencies, separating said signal currents into various frequency bands, modulating the carrier frequency current with the various signal current bands and differently affecting the transmission characteristics of the various resulting modulated carrier frequency currents the carrier energy modulated by each band having a distant transmission characteristic.

18. The method of radio communication which comprises producing a carrier fre-

quency current, producing signal currents of varying frequencies, modulating said carrier frequency current with said signal currents, differently polarizing and transmitting the resulting modulated carrier frequency in accordance with various frequency bands of the signal currents, receiving all of the transmitted energy and combining the received energy to reproduce the original signal currents.

19. The method of radio communication which comprises producing a carrier frequency current, producing signal currents of varying frequencies, modulating said carrier frequency current with said signal currents and transmitting the resulting modulated carrier frequency under different transmission characteristics in accordance with various frequency bands of the signal currents.

20. The method of radio communication which comprises producing a carrier frequency current, producing signal currents of varying frequencies, modulating a portion of said carrier frequency current with a portion of the signal currents, modulating another portion of the carrier frequency current with another portion of said signal currents, and differently polarizing each portion of the resulting modulated carrier frequency in accordance with the frequencies of the signal current modulated therewith.

21. The method of radio communication which comprises producing a carrier frequency current, producing signal currents of varying audio frequencies, separating said signal currents into various frequency bands, modulating the carrier frequency current with one of said signal current frequency bands, polarizing the resulting modulated carrier frequency current, modulating the carrier frequency current with another of said signal current frequency bands, and differently polarizing the resulting modulated carrier frequency current.

22. The method of radio communication which comprises, producing a carrier frequency current, producing signal currents of varying audio frequencies, separating said signal currents into various frequency bands, modulating the carrier frequency current with the various signal current bands, and differently polarizing the various resulting modulated carrier frequency current in accordance with the separated signal current frequency bands.

23. In a radio communication system, a source of carrier frequency current, a source of signal currents of varying frequencies, means for segregating signal currents from said source into various frequency bands, means for modulating the carrier frequency current with each of said segregated bands and means for differently polarizing the various resulting modulated carrier frequency currents.

24. In a radio communication system, a source of carrier frequency current, a source of signal currents of varying frequencies, means for segregating signal currents from said source into various frequency bands, means for modulating the carrier frequency current with each of said segregated bands, means for differently polarizing and transmitting the various resulting modulated carrier frequency currents, means for receiving the transmitted energy and means for combining all of the transmitted energy to reproduce the original signal currents.

25. The steps in a method of communication which comprise generating electrical energy representative of the signals desired to be communicated, separating the generated electrical energy into various predetermined frequency bands, generating carrier currents, separately combining each of the separated bands with a carrier and transmitting under different transmission characteristics the energy resulting when each band is combined with a carrier.

26. The steps in a method of signalling which comprise generating electrical energy representative of the signals desired to be communicated and separating the generated signal energy into various frequency bands of predetermined width, generating carrier frequency energy, transmitting a portion of the generated carrier frequency energy polarized in one plane, transmitting another portion of the transmitted carrier frequency energy polarized in another plane, and combining the signal energy with either one or the other of said portions of carrier frequency energy, depending upon the frequency of the signal energy.

JOHN HAYS HAMMOND, JR.