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PRIVACY SYSTEM

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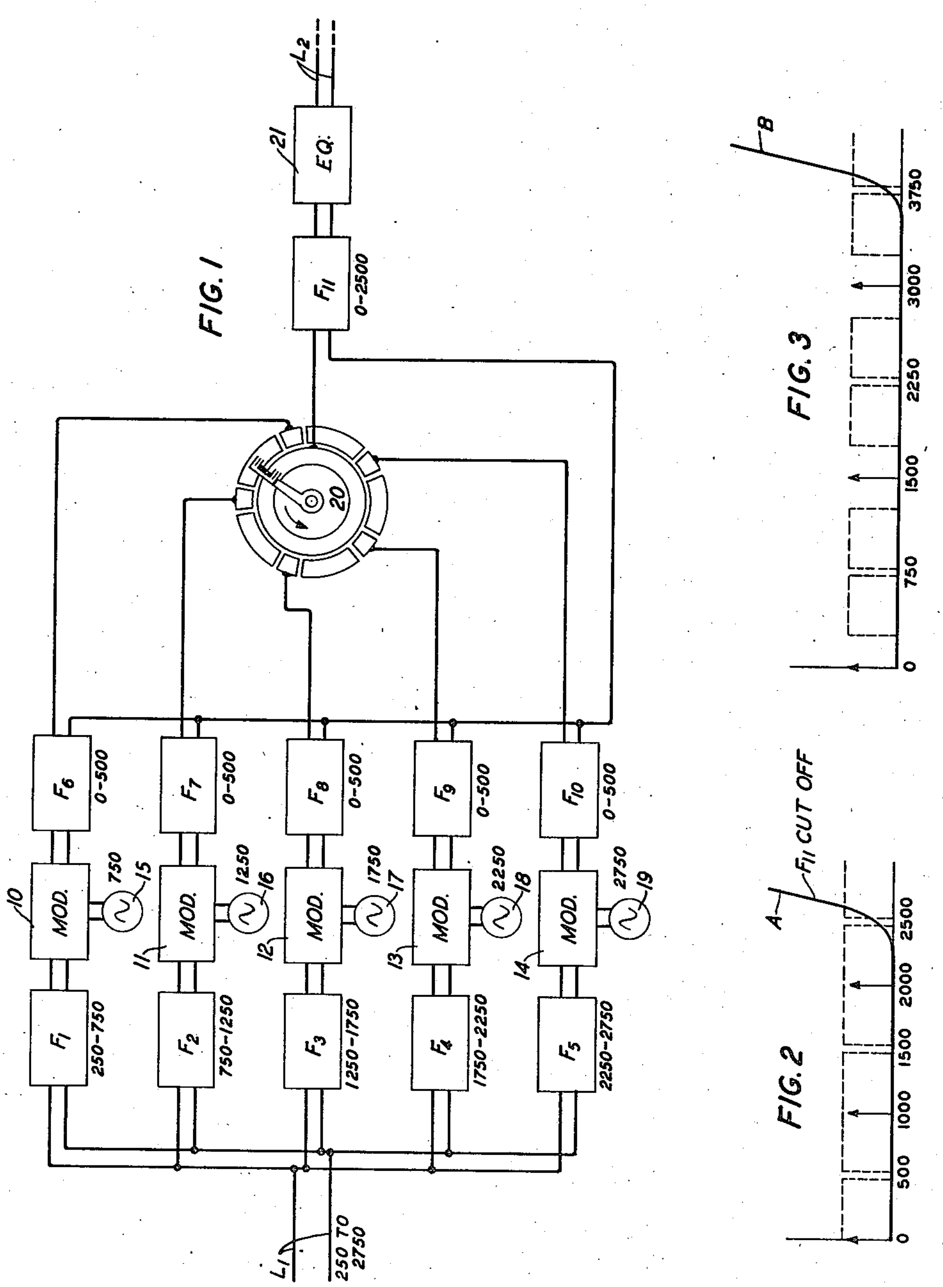

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PRIVACY SYSTEM

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4 Claims. (Cl. 179—1.5)

The present invention relates to systems and methods of transmission with privacy. It is appreciable to line wire or radio transmission, and to the sending of speech messages or any other type of signals which comprise a band of frequency components such that the signal wave band can be subdivided into narrower subbands.

A general object of the invention is to increase the difficulty of unauthorized reception of the signal or other wave being transmitted.

Prior art systems have been devised which required for successful reception the provision by the listener of a wave of proper frequency, the selection of particular received frequencies and the rejection of others. Various means have been suggested to increase the difficulty of hitting upon the right frequency to be used and the band to be selected from incoming waves.

The present invention in its preferred form renders successful reception very difficult without a knowledge of the scheme of wave transformation used, by placing strict requirements on both the frequency and phase relations which must be observed for successful reception.

In accordance with the invention the message waves are subdivided into narrow bands which are simultaneously transmitted on a time-division or phase-discrimination basis, similarly to multiplex transmission, whereby the subbands are separately reproduced at the receiver. They are then combined in proper manner to reconstruct the message waves.

The various features and objects of the invention will be made clear from the following detailed description of an illustrative embodiment.

In the drawing,

Fig. 1 is a schematic diagram of the apparatus which may be used at one terminal of the system in accordance with the invention; and

Figs. 2 and 3 are frequency diagrams to be referred to in the description.

Referring first to Fig. 1, the incoming line L_1 from any suitable signal source such as a telephone transmitter is connected in multiple to the subdividing band filters F_1, F_2, F_3, F_4 and F_5 which subdivide the incoming wave band into (in this case) five subbands, each 500 cycles wide by way of example. The band limits are given on the drawing for illustrative purposes. The output side of each filter is connected to a corresponding modulator 10 to 14, inclusive, each of which is supplied by a wave of appropriate frequency from a wave source 15, 16, etc. to step the frequencies down to the range of zero to 500 cycles. Modulator 10, for example, is supplied with a frequency of 750 cycles, this being the upper cut-off frequency of the filter F_1. This results in the production of upper and lower side-bands, the lower side-band extending from zero to 500 cycles. The filter F_6 suppresses the upper side-band and may assist the modulator 10 in suppressing the unmodulated carrier component. The same sort of action occurs in each of the other modulators. These modulators are preferably of the balanced or carrier suppression type.

Each of the filters F_6 to F_{10} has one terminal common to one terminal of the outgoing line L_2. The other terminal of each filter F_6 to F_{10} is connected to a different one of the five segments of the rotary distributor 20, the rotating arm of which is connected to the remaining side of the outgoing line L_2. The filter F_{11} is used in the outgoing line to limit the transmitted band to the range of zero to 2500 cycles and equalizer 21 equalizes the line for constant attenuation over the frequency band and linear phase shift.

The rotating arm of the distributor 20 is driven at a highly constant speed which is at least as great as 1000 revolutions per second or twice as high as the highest frequency to be sent. The active segments of the commutator are shown as relatively short leaving relatively long idle spaces between. This is in accordance with the theory and practice disclosed in W. R. Bennett application, Serial No. 221,298, filed July 26, 1938. As disclosed in the Bennett application the use of a proper switching function results in the production of side-bands on a succession of carrier waves harmonically related in frequency and of equal amplitude. When these relations hold, the frequency band transmitted may be limited to the product of the number of channels by the band width of one channel, and the cross-talk between channels may be made ideally zero. The proper switching function is controlled by the speed of rotation of the distributor arm and the shape and relative length of the active segments.

The relation of the side-bands and "carrier" wave components in the system as described in Fig. 1 is illustrated in the diagram of Fig. 2. Five side-bands are present extending from zero to 2500 cycles The carriers in this case have frequencies of zero, 1000 cycles and 2000 cycles. Since no direct current is supplied to the distributor, the carrier frequency components are not actually produced. The lowest side-band extends from zero to 500 cycles and is based upon a direct current carrier. The 1000 cycle carrier has lower and upper side-bands extending downward to 500 cycles and upward to 1500 cycles and the 2000 cycle carrier wave has upper and lower side-bands extending downward to 1500 cycles and upward to 2500 cycles. (For clarity in illustration a slight gap is shown between the upper side-band and the lower side-band of the next higher carrier, although theoretically no gap need exist in these points.) The rotary distributor, of course, produces side-bands based on higher frequencies than those illustrated but these are removed by the filter F_{11} which is designed to have a sharp cut-off to suppress frequencies above 2500 cycles. Since it is impossible for a filter to provide an infinitely sharp cut-off so as completely to separate two adjacent side-bands, the filter may advantageously be designed in accordance with the principles disclosed in Nyquist Patent 1,748,486, February 25, 1930, according to which the cut-off (indicated at A in Fig. 2) is made gradual and at such a rate that the resulting distortion of the wanted frequencies near the edge of the band is compensated by frequencies lying on the other side of the desired limiting frequency of the selected band.

The diagram of Fig. 2 illustrates the frequency relations but not the phase relations of the different channels. The three carriers shown may be visualized as modulated in zero phase by the signal from filter F_6 to produce all of the side-bands illustrated in Fig. 2. This occurs by the passage of the rotating arm over the corresponding commutator segment. These wave components, however, persist in time after the brush has passed off the segment to which the upper channel is connected. This will be evident from noting that the band width transmitted is limited by the filter F_{11} to a comparatively narrow range. The high frequencies required by the Fourier analysis to extinguish the frequencies resulting from any one channel at all times except when the brush is in contact with the corresponding segment, are not permitted to be transmitted. The side-band frequencies of one channel are, therefore, present on the line at the same time as frequencies produced by others of the channels. The same frequencies illustrated in Fig. 2 are produced by passage of the rotating brush over each of the succeeding channel segments but with successive phase displacements.

Reception of the wave is accomplished by a station at the opposite end of the line L_2 which may be the exact counterpart of that shown in the drawing and which, therefore, has not been illustrated. The action may be understood by considering a wave incoming on line L_2 from a distant station, considering Fig. 1 as the receiving station. It is assumed that the rotating brushes at the two stations are in exact synchronism and phase. The passage of the rotating brush over the segment of a particular channel results in the production of a set of waves in such phase as to reproduce the subband corresponding to that channel by arithmetical addition of the components from all five side-bands (see Fig. 2). At the same time the phase displacement between the waves produced by the receiver distributor and the incoming side-bands representing the other four channels are such that in the ideal case all of the detected or demodulated components of those other channels add to zero. When the brush passes onto the next segment the phase relations are right for reproducing the signal corresponding to that channel and for producing a zero resultant for the signals belonging to the other channels.

It is seen, therefore, that successful reception requires exact frequency and phase relations to be observed. Moreover, the correct relations for receiving waves corresponding to one only of the subbands would not yield intelligible signals, assuming that the subbands are chosen for sufficiently low intelligibility.

The requirement of transmitting a direct current component over the line as in the system of Fig. 1 may be avoided by changing certain of the constants of the system as will now be described in connection with Fig. 3. In this case the filters corresponding to F_6 to F_{10}, inclusive, each pass the band of 250 to 750 cycles and the switching frequency of the commutator is 1500 cycles. In this case modulator 10 and filter F_6 may be omitted since the filter F_1 already provides the band from 250 to 750 cycles which may be directly sent to the distributor. Modulators 11 to 14, inclusive, would now be supplied with frequencies 250 cycles greater than those indicated on the drawing for the sources 16 to 19, inclusive.

As seen from Fig. 3, the carrier frequencies in this case would be zero, 1500 cycles and 3000 cycles. As in the previous case, however, the carrier frequencies themselves are not transmitted. The lowermost side-band extends from 250 to 750 cycles and the other side-bands are as shown in the diagram. The cut-off characteristic of filter F_{11} for this case is indicated at B.

The foregoing description is based upon the use of a mechanical type of distributor. It is clear, however, that the only requirement is that of producing sets of side-bands based upon carrier waves of proper frequency and phase relations and any terminal apparatus capable of accomplishing these effects may be used to practice the invention. An electronic type of rotary distributor suitable for use in the invention is disclosed in United States patent application Serial No. 192,471, filed February 25, 1938, of P. Mertz, issued as U. S. Patent No. 2,185,693, Jan. 2, 1940. As in the case of the mechanical distributor illustrated herein, the shape and length of the segments must be properly chosen in case an electronic distributor is used. Moreover, terminal apparatus utilizing a harmonic generator for producing the carrier waves, delay networks for producing the phase shift and modulators for producing the sidebands may be used as disclosed in United States patent application of E. Peterson, Serial No. 221,297, filed July 26, 1938, for building up the sets of side-bands based on carriers properly displaced in phase.

The invention is not to be construed as limited to the structural details nor to the magnitudes given in the foregoing description but its scope is defined in the claims.

What is claimed is:

1. The method of transmitting message waves with privacy comprising subdividing the waves into frequency subbands in different circuits, reducing the subbands to occupy the same absolute frequency limits, transmitting the resulting subband waves as modulations of the same set of carrier waves, the modulations by the respective subband waves being displaced in phase and utilizing the phase displacement between the modulated waves to distinguish the several message subband waves from one another.

2. In transmission of message waves with privacy, the method comprising subdividing the message waves into frequency subbands, shifting the frequency of certain subbands so that all subbands occupy the same frequency limits, produc-

ing from one subband, modulations of harmonically related carrier waves in one phase, producing modulations of the same carrier waves in different phase by another of the subbands and utilizing the phase displacement between the modulated waves to distinguish the several message subband waves from one another.

3. In a privacy system, a source of signal waves comprised in a band of frequencies, subband selective circuits and frequency shifting circuits for deriving from the signal waves a plurality of subbands of waves taken from different portions of the signal band but shifted to occupy the same absolute frequency subband limits, means to produce from the first such subband a number of modulation side-bands of different frequency equal to the number of subbands into which the signal waves are subdivided, means to produce a like number of side-bands of the same respective frequencies in the case of the second subband, and so on, including means to produce equal phase rotations between the side-bands produced from one subband and those produced from the next, and means to transmit the resulting side-bands.

4. A receiving system from signals transmitted in the form of successions of discrete side-bands, each side-band in the same succession representing components taken from one portion of the signal band and repeated over and over again throughout the total frequency range embraced by the side-bands, one succession of side-bands being rotated in phase with respect to another, said system including a plurality of circuit branches and a receiver common thereto, and comprising demodulating means operating in such frequency and phase as to reproduce in each circuit the signal components represented by a respective succession of side bands with substantial suppression of the components represented by other successions of side-bands, and means to combine in said receiver the signal components reproduced in the several circuits.

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