

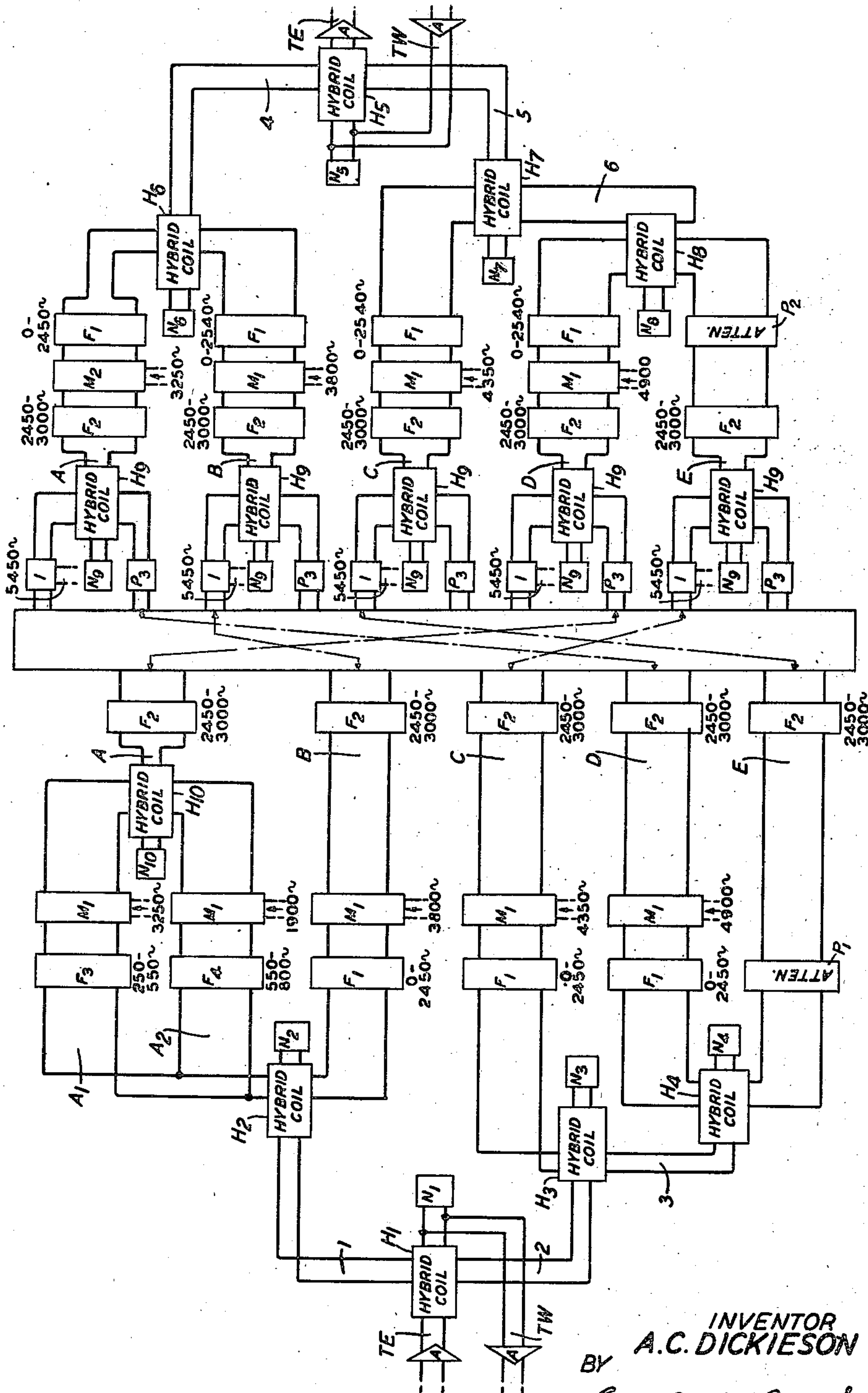
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PRIVACY SYSTEM

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PRIVACY SYSTEM

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This invention relates to signal wave transmission systems and particularly to circuits for rendering signal transmission over such systems unintelligible to unauthorized listeners.

The invention is particularly applicable to secrecy or privacy systems of the band-splitting and scrambling type, such as disclosed, for example, in my U. S. Patent 2,132,205, issued October 4, 1938. In the system of that patent the whole frequency band of the speech or other signal wave to be transmitted is shifted by modulators in separate circuits to respectively different higher positions in the frequency spectrum with a certain frequency range within the frequency limits of the original signal wave common to all of the shifted bands, this common frequency subband being selected by a filter in each circuit. The selected subbands are interchanged, with or without inversion of the frequencies in certain of the interchanged subbands, among the several circuits in accordance with selected secret combinations which are changed from time to time. Other modulators in the respective circuits are used to shift the interchanged subbands downwards to adjacent positions in the frequency spectrum embracing a total frequency range substantially equal to that of the original signal frequency band. The subbands in the latter shifted positions are superposed in a common circuit and transmitted together over the line or other transmission medium to a receiving station where by apparatus which is the same as used at the transmitting station but operating in reverse order they are transformed to reproduce the original intelligible signal wave.

It is known that the intelligibility of a subband divided out of a speech band depends not only on the frequency width of the subband but also on its location in the speech band. If the important band of frequencies, 250–3000 cycles, in a speech wave is divided into a plurality of, say five, subbands, A to E, of equal width (550 cycles), it has been determined by listening tests that the lower frequency subband (250–800 cycles), which will be referred to hereinafter as the A subband, has substantially 100 per cent sentence intelligibility, and that the sentence intelligibility for the other subbands rapidly decreases as the position in the frequency spectrum becomes higher.

The efforts of an ordinary eavesdropper making use of a heterodyne carrier of adjustable frequency to find the A subband and thus to listen in on a conversation over a system employing a band-splitting and scrambling privacy system such as described above, may be circumvented by

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proper choice of the interchanged subband combinations so that, if he tunes the A subband into its proper location, one of the other subbands will be superimposed and, therefore, masking. However, a more determined and skillful eavesdropper equipped with more complicated apparatus may be able to find the A subband and pick it out free of any masking frequencies. One way of circumventing such an eavesdropper is to employ narrower subbands and to have their frequency positions switched more frequently. If the subbands are kept of equal width, it would be necessary to go to a ten subband system to get any appreciable improvement in privacy by such means, which would double the size and cost of present systems employing five subbands.

An object of the present invention is to increase the privacy of privacy systems of the type described above without increasing the number of subbands switched and with the addition of comparatively little and economical apparatus. This object is attained in accordance with the invention by arrangements operating to introduce additional distortion in the particular subband having the greatest amount of sentence intelligibility while maintaining the general scheme of frequency transformation and switching described above.

The various objects and features of the invention will be understood from the following detailed description when read in conjunction with the single figure of the drawing showing diagrammatically one terminal of a two-way telephone system employing a bilateral privacy device of the band-splitting and scrambling type modified in accordance with one embodiment of the invention.

The privacy or secrecy system of the invention will be described as applied to a voice-frequency telephone system although its basic principles are applicable to other types of signaling systems and to higher frequencies.

In the two-way telephone terminal of the drawing, the bilateral privacy device is shown connected between portions of the one-way transmission circuit TE transmitting in the direction from west to east and portions of the one-way transmission circuit TW transmitting in the direction from east to west, so as to allow transmission over each of these transmission circuits through the privacy device while maintaining a conjugate relationship between the two circuits.

The privacy device employs five band-splitting branches or channels identified as A to E, respectively. At the west end of the circuit the incom-

ing portion of the one-way circuit TE and the outgoing portion of the one-way circuit TW are coupled by the hybrid coil H₁ and associated balancing network N₁ to the two circuits 1 and 2. The circuit 1 is coupled by hybrid coil H₂ and associated network N₂ with channels A and B. The circuit 2 is coupled by hybrid coil H₃ and associated balancing network N₃ with the channel C and the circuit 3; and the circuit 3 is coupled by hybrid coil H₄ and associated balancing network N₄ with the channels D and E.

At the east end of the circuit, the outgoing portion of circuit TE and the incoming portion of circuit TW are coupled by hybrid coil H₅ and associated balancing network N₅ with the circuits 4 and 5. The circuit 4 is coupled by hybrid coil H₆ and associated balancing network N₆ to the east ends of channels A and B. The circuit 5 is coupled by hybrid coil H₇ and associated balancing network N₇ with the east end of channel C and a circuit 6. The circuit 6 is coupled by hybrid coil H₈ and associated balancing network N₈ with the east ends of channels D and E.

The channels B to D include in order reading from west to east: a filter F₁; a modulator M₁; a filter F₂; two parallel circuits respectively including an inverter I and an attenuation pad P₃ providing a circuit loss equal to that of the inverter I, having their east ends coupled with the east portion of the same channels B to D, respectively, by equivalent hybrid coils H₉ and associated balancing networks N₉; a second filter F₂; a second modulator M₂; and a second filter F₁. The channel E contains the same elements connected in the same order as the channels B to D except that an attenuation pad P₁ and an attenuation pad P₂, respectively, providing a circuit loss equal to that of the modulator M₁ and the first filter F₁ and the modulator M₂ and second filter F₁ in the other channels are substituted for the latter modulators and filters.

The channel A differs from the channels B to D in that its input portion comprises two branch circuits A₁ and A₂ having their west ends connected in parallel to the circuit leading to the hybrid coil H₂ and their east ends coupled by hybrid coil H₁₀ and associated balancing network N₁₀ to the west end of the filter F₂. The branch A₁ includes a filter F₃ and a modulator M₁ and the branch A₂ includes a filter F₄ and a modulator M₁, substituted in place of the first filter F₁ and modulator M₁ employed in the single circuit of each of the channels B to D.

Associated with each of the channels A to E at a point between the first filter F₂ and the parallel inverter and attenuation pad branches in front of the second filter F₂ is a switching circuit indicated by a box labeled SW, the function of which is to connect the first filter F₂ of each channel with the inverter I or the attenuation pad P₃ of the same or any of the other channels to scramble up the frequency subbands selected by that filter in the several channels in accordance with any one of a number of selected secret combinations, with or without inversion of those frequencies within the individual subbands depending on whether the filter F₂ is connected to an inverter or an attenuating pad. The switching arrangements SW may be of the type illustrated in Chesnut et al. Patent 1,829,783, issued November 3, 1931, and may be synchronized with the similar switching arrangement at the other terminal of the system in the manner described in that patent.

Each of the filters F₁ in the four channels A to

D are identical low-pass filters passing the same speech frequency range 0-2450 cycles per second, and each of the filters F₂ in the channels A to E are identical band-pass filters passing the frequency range, 2450-3000 cycles per second. The filter F₃ in branch A₁ of channel A is a band-pass filter passing the frequency range 250-550 cycles, and the filter F₄ in the branch A₂ of channel A is a band-pass filter passing the frequency range 550-800 cycles.

Each of the modulators M₁, M₂ in the channels A to E are bilateral modulators, preferably of the known double-balanced copper-oxide type. The modulator M₁ in branch A₂ of channel A is supplied with a carrier frequency of 3250 cycles; the modulator M₁ in branch A₁ of channel A is supplied with a carrier frequency of 1900 cycles; and the modulator M₁ in channels B to D is supplied with the carrier frequencies 3800, 4350 and 4900 cycles, respectively. The modulators M₂ in the channels A to D are supplied with a carrier frequency of 3250, 3800, 4350 and 4900 cycles, respectively. The inverters I in the inverter branches of the channels A to E are supplied with a carrier frequency of 5450 cycles. All of these carrier frequencies may be supplied by a single tone generator of the inductor type, such as is described in H. M. Stoller Patent 1,637,233, issued October 9, 1928.

For the case of speech wave transmission through the privacy device from west to east the operation is as follows. Let it be assumed that a speech wave having a frequency band of 0-3000 cycles is received at the west end of the privacy device over the circuit TE. The energy of this wave is divided into two parts by the hybrid coil H₁, which pass into the circuits 1 and 2, respectively. The portion of the waves in circuit 1 is divided into two energy portions by hybrid coil H₂ which respectively pass into channel A and channel B. The portion of the speech energy in circuit 2 is divided into two parts by hybrid coil H₃, which pass respectively into channel C and circuit 3. The speech energy in circuit 3 is divided by hybrid coil H₄ into channels D and E. Thus the incoming speech wave is divided into five energy portions respectively transmitted into the five privacy channels A to E.

The speech energy in channel A in the frequency range 250-300 cycles, which, as stated above, is the range which has the greatest amount of sentence intelligibility, is divided into two equal portions of frequency range 250-550 cycles and 550-800 cycles by the parallel filters F₃ and F₄ in the branches A₁ and A₂ of channel A passing these respective frequency bands.

The frequency range 250-550 cycles is modulated with a carrier of 3250 cycles in the modulator M₁ in branch A₁, yielding a lower side-band of 3000-2700 cycles, and the frequency range of 550-800 cycles is modulated with a carrier of 1900 cycles, giving an upper side-band of 2450-2700 cycles. As the outputs of the two modulators M₁ in the branches A₁ and A₂ are coupled through hybrid coil H₁₀ and associated balancing network N₁₀ to the input of the first filter F₂ in the channel, passing the same frequency range, 2450-3000 cycles, as the corresponding filter F₂, in the output of the modulator M₁ in the channels B to D and in the output of attenuator D, in channel E, the A subband range is placed in the common band filter frequency range so that it can be switched in the usual manner between the outgoing portions of the channels A to E by the switching device SW, but in the process, the A

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subband has been cut approximately in half and the frequencies in the two halves inverted with respect to each other.

Now if an eavesdropper uses a band filter of 550 cycles in width and tunes in the lower part of the A subband, he will receive the 250-550 cycle part in its right location, with the 550-800 cycle part adjacent but with its frequencies inverted. Thus, in addition to the reduction in intelligibility due to the masking provided by the adjacent inverted speech band, the intelligibility will be further substantially decreased due to the inversion of the frequencies in the two halves of the A band.

The operation of the remaining portion of the system of the drawing will be the same as described in my aforementioned patent for the correspondingly identified circuit elements and need not be repeated here.

When speech signals are being transmitted in the direction from east to west, the operation will be the reverse of that described with the frequencies passed through the left-hand 2450-3000 cycle filter F_2 , in the direction from east to west in the channel A divided by hybrid coil H_{10} and associated balancing network N_{10} into two equal energy portions in the branch circuits A_1 and A_2 . These are respectively modulated with carriers of 3250 and 1900 cycles in the modulators M_1 in the two branches to reproduce the original 250-550 cycle and 550-800 cycle subbands with their frequencies in proper order which are selected by filters F_3 and F_4 , respectively, are combined in the outputs of these filters and pass through the hybrid coils H_2 and H_1 to the outgoing portion of the transmission circuit TW at the east terminal where they are combined with the other frequencies transmitted in the east-to-west direction over the channels B to E in the manner described in my aforementioned patent, to reproduce the original signal waves with all frequencies in proper intelligible order.

It will be apparent that the intelligibility of the transmitted signals to an eavesdropper may be further decreased if the B subband which is next in sentence intelligibility also be split into two halves and the frequencies in the two halves inverted in the manner which has been described for the subband A. Other modifications of the circuits illustrated and described which are within the spirit and scope of the invention will be apparent to persons skilled in the art.

What is claimed is:

1. The method of transmitting a message with privacy which consists in deriving from a message wave having a band of frequency components, a plurality of frequency subbands having the same frequency limits but the frequencies in each subband representing respectively different frequency ranges in the original message band, and with the frequencies in the two halves of the subband corresponding to that frequency range in the original message band having the greatest amount of intelligibility inverted with respect to each other, interchanging said subbands among several circuits, and transmitting the interchanged subbands.

2. The method of making a transmitted message unintelligible which consists in transforming a message wave of a band of frequency components into a plurality of relatively narrow subbands each having the same frequency limits but the frequencies in each subband representing respectively different frequencies in different frequency ranges of the original message band, sep-

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arately selecting from the original message band a subband having a relatively large amount of intelligibility, transforming the latter subband to produce another subband having the same frequency limits as each of said plurality of subbands but with the frequencies in two approximately equal portions inverted with respect to each other, interchanging said plurality of subbands and said other subband among several circuits, and transmitting the interchanged subbands.

3. In a speech privacy system, means to derive in a plurality of separate circuits a plurality of narrow bands of waves of equal band width from different portions of the speech frequency band, each such narrow band being practically unintelligible by itself but one of said bands carrying a larger amount of intelligibility than the others, means to shift said narrow bands of waves about among themselves and to transmit them to a distance in such shifted order to provide privacy, and means to increase the privacy comprising means to subdivide said one band having the larger amount of intelligibility into frequency subbands and the rearrange the frequency relations of certain of the subbands to reduce their intelligibility.

4. A privacy system comprising means for transforming a message wave of a band of frequency components into a plurality of frequency subbands each having the same frequency limits but the frequencies in each subband representing those in respectively different frequency ranges of the original message band and with the frequencies in the two halves of the one of said subbands having the greatest amount of intelligibility inverted with respect to each other, means for interchanging all of said subbands including said one subband among an equal number of circuits, and means for superposing the interchanged subbands in a common circuit for transmission.

5. A privacy device comprising a plurality of circuits each supplied with the whole frequency band of a signal wave to be made secret, modulating and filtering means in one of said circuits for transforming the subband of the supplied signal wave having a relatively large amount of intelligibility compared with the other subbands into another narrower subband in a predetermined position in the frequency spectrum and with the frequencies in the two halves of the latter subband inverted with respect to each other, modulating and filtering means in the other circuits for respectively transforming the supplied signal band into a plurality of subbands each having the same frequency limits as said other subband, the frequencies in the several subbands representing respectively different frequency ranges in the original signal band, means for interchanging all of the transformed subbands including said other subband among said circuits in a predetermined arrangement, and means for combining the interchanged subbands in a common circuit for transmission.

6. A privacy system comprising a plurality of circuits each supplied with the same band of frequency components representing a message to be made secret, means in each circuit for shifting the supplied band to a different respective position in the frequency spectrum such that each shifted band has a subband of frequencies in common with each of the other shifted bands within the frequency range of the original message band, means in each circuit for selecting the common subband, means for interchanging

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the selected subbands among the several circuits, with or without inversion of the frequencies within the interchanged subbands, means in each circuit for shifting the interchanged subbands so that all interchanged bands have adjacent respectively different frequency positions embracing substantially the same total frequency range as the original message band, a common circuit, means for impressing the interchanged subbands in their final shifted frequency positions superimposed on one another upon said common circuit for transmission, and means for inverting with respect to each other the frequencies in two substantially equal portions of the one of the common subbands in one circuit representing the frequency range in the original message band having the maximum amount of intelligibility, prior to selecting it and interchanging it with the other subbands.

7. The privacy system of claim 6, in which the last-mentioned means comprises two parallel branches in the input of said one circuit, each including means for selecting a different half of said one frequency range in the supplied message band, having said maximum amount of intelligibility, modulating means in each branch for individually modulating the selected half of said one frequency range with a wave of selected frequency so that the modulation products in the two branches respectively include an upper and lower message side-band of respectively inverted frequencies which together comprise said common subband of frequencies and means for impressing said upper and said lower side-band in superposition on said common subband selecting means in said one circuit.

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8. A privacy system comprising a wave transmission medium connecting station, the transmitting stations comprising a plurality of parallel circuits each supplied with the same band of frequency components representing a message to be transmitted, means in each circuit for shifting the supplied band to a different respective position in the frequency spectrum such that each shifted band has a subband of frequencies in common with each of the other shifted bands, means in each circuit for selecting the common subband, means for interchanging the selected subbands among the several circuits in a predetermined arrangement, means in each circuit for shifting the interchanged subbands so that the interchanged subbands have adjacent respectively different positions in the frequency spectrum embracing substantially the same total frequency range as the original message band, means for transmitting the interchanged subbands in their final shifted frequency positions superimposed on one another to said medium, means for rearranging the frequency relations of different parts of the one of the selected subbands having the greatest amount of intelligibility prior to interchanging the selected subbands among the several circuits to further reduce the intelligibility of the message wave, said receiving station comprising the same circuits and means as the transmitting station as recited above but connected in reverse order for reproducing the original message wave from the wave received thereby from said medium.

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