June 11, 1946. A. V. LOUGHREN 2,402,058

SECRECY COMMUNICATION SYSTEM

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FIG. 1.

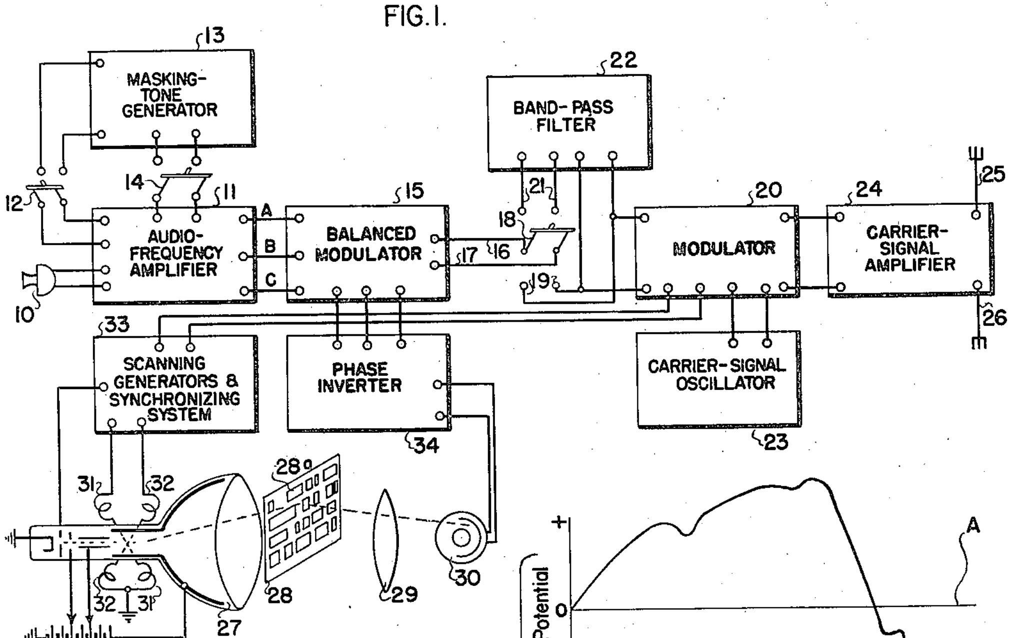
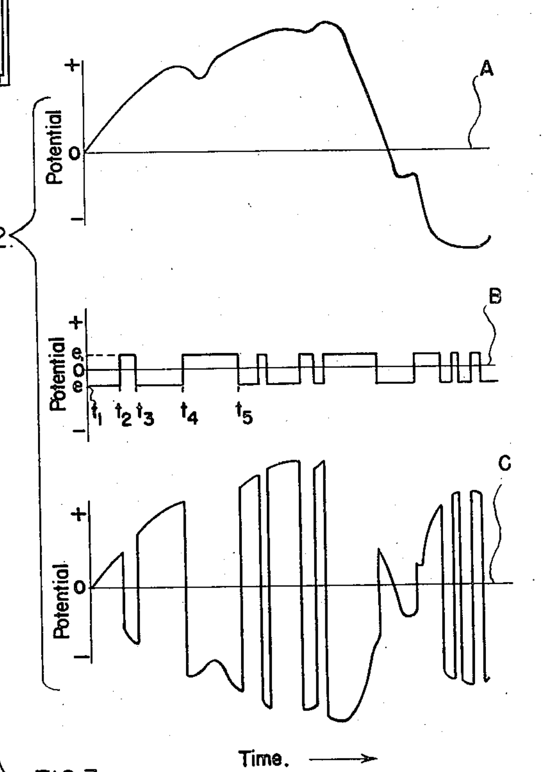


FIG. 2.



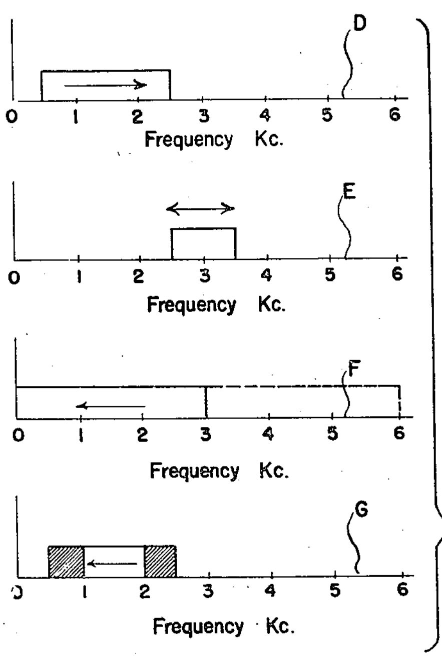


FIG. 3.

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FIG. 4.

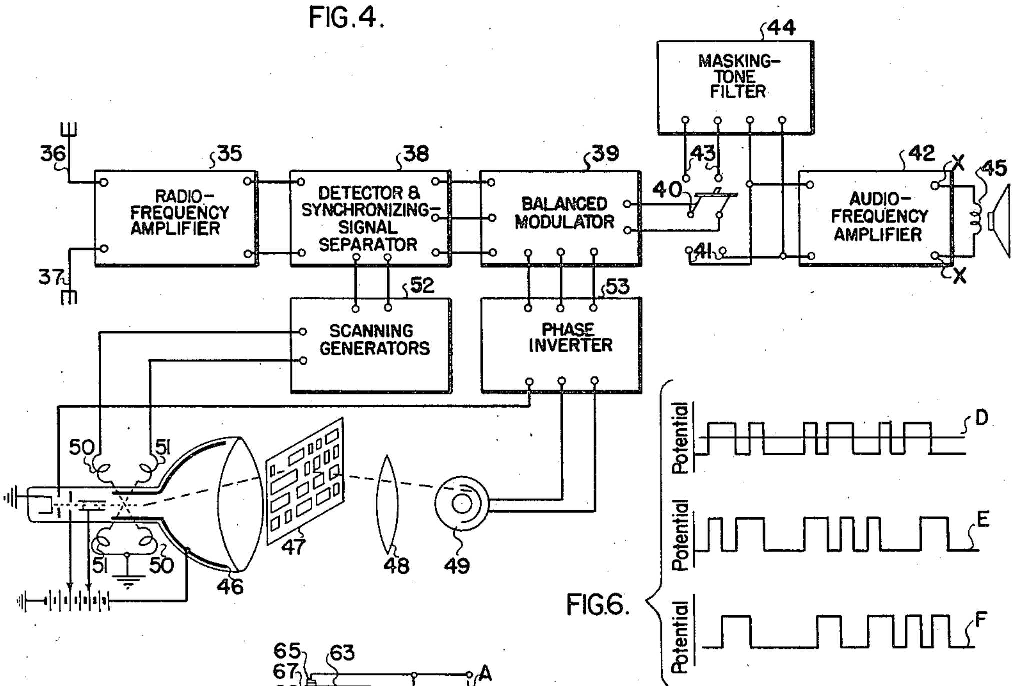

FIG. 6.

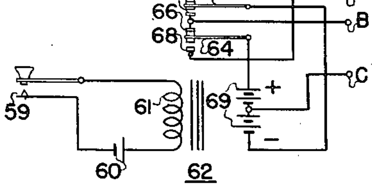

FIG. 5.

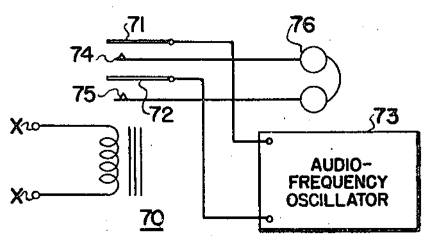

FIG. 7.

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UNITED STATES PATENT OFFICE

2,402,058

SECRECY COMMUNICATION SYSTEM

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Application June 25, 1941, Serial No. 399,637

18 Claims. (Cl. 179—1.5)

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The present invention relates to secrecy communication systems and, particularly, to secrecy communication systems of the type wherein the intelligibility of signals to be transmitted is substantially completely destroyed, prior to transmission thereof, by modifying a given characteristic of a signal by means of a random-frequency control signal. Intelligibility is restored at the receiver by operating on the signal thus transmitted in inverse manner to that at the transmitter.

There has long existed a need for a secrecy communication system which insures a considerable amount of secrecy and which is adaptable for use with existing speech communication channels. Such systems are especially desirable for radio communication, which is easily intercepted by unauthorized persons. A communication system of this nature is considered satisfactory from a practical standpoint only when unauthorized reception of communications is practically impossible even though an unauthorized person has a complete receiving apparatus capable of rendering the received signals intelligible and lacks only information concerning the pre-established procedure by which the transmission is rendered unintelligible, for example, a code disc or pattern.

One proposed form of secrecy communication system of the prior art comprises an arrangement for alternately transmitting desired signals and noise signals, the alternate transmission occurring in an irregular manner in accordance with a time sequence plan. The receiver includes apparatus similar to that used at the transmitter which, when operated in accordance with the time sequence plan of transmission, effectively removes the interjected noise thereby to leave only the desired signal. The apparatus at the transmitter used for interjecting the noise into the signal and the corresponding apparatus used at the receiver for removing the interjected noise are synchronized in their operation by synchronizing signals included in the transmission. This prior art arrangement has the disadvantage that, when the transmission is received and reproduced in conventional manner without specifically removing the noise interjected at the transmitter, the communication may be frequently understood by an unauthorized person since the desired signal is simply reproduced against a background of disturbing noise. In the event that the noise interjected at the transmitter has large intensity and the interjection occurs at a high frequency, whereby the communication when reproduced in conventional

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manner cannot be understood by an unauthorized person against the high level of background noise, there is the disadvantage that the quality of the transmission may be seriously impaired when reproduced by an authorized listener.

It has been proposed in accordance with another prior art secrecy communication system, particularly adaptable to speech transmissions, to employ a speech-frequency heterodyne oscillator and to establish secrecy by transmitting only the lower sideband of the resulting heterodyne components, thus inverting the speech frequencies of the transmitted signal. The heterodyne oscillator frequency in this arrangement is maintained constant over an interval of time, but is changed from time to time in accordance with a prearranged plan. Intelligibility of the speech is restored at the point of reception by adding to the received signal similar heterodyne oscillations having a frequency varying in the same manner as that of the heterodyne oscillator at the transmitter. Thus it is only necessary for an unauthorized listener to supply the correct heterodyne frequencies to the received signal to restore intelligibility of the communication. This may be done by the method of trial and error. A proposed improvement of this system is the transmission of certain portions of the range of speech frequencies in normal manner and other portions in inverted manner and periodically to change, in accordance with a preconceived plan, the portions of the speech-frequency range which are transmitted in normal and inverted fashion. Here again an unauthorized person may restore intelligibility of the communication by trial and error, though with somewhat greater difficulty, it being only necessary to determine the correct frequency of the transmitter heterodyne oscillator, a fact which can be established when portions of the communication become intelligible, and thereafter by trial and error to combine in proper order the normal and inverted portions of the range of speech frequencies. This prior art arrangement has a further disadvantage that band-pass filters must be used for separating the speech-frequency range into the aforementioned portions and corresponding filters at the transmitter and receiver must be unusually well designed and carefully balanced to avoid severe impairment of the quality of the reproduced speech.

It is an object of the invention, therefore, to provide a new and improved secrecy communication system which avoids one or more of the disadvantages and limitations of the prior art systems of this nature.

It is an additional object of the invention to provide a secrecy communication system wherein satisfactory reception of communications is premised upon the authorized listener having and following certain requisite information concerning the plan of communication and in which unauthorized interception is rendered practically impossible even though the unauthorized listener has a complete complement of apparatus necessary for continuous and satisfactory reception of the communications but lacks only the plan of communication.

In accordance with the invention, a secrecy communication system comprises a source of signals to be transmitted, means for developing a random-frequency control potential, a signal-translating channel, and means coupled to the source and responsive to the control potential for applying to the channel signals of normal phase when the potential has a first value and for applying to the channel signals of opposite phase when the potential has a second value, whereby the signals translated by the channel have mutilated wave form and would not be intelligible if reproduced in conventional manner. The system includes means for developing a second random-frequency control potential having the same wave form as, and substantially synchronous with, the first control potential, a signal-reproducing device, and means adapted to have applied thereto signals translated by the channel and responsive to the second control potential for applying to the reproducing device translated signals of one phase when the second potential has a first value and for applying to the device translated signals of opposite phase when the second potential has a second value, whereby the signals applied to the device are reproduced thereby with substantially the full intelligibility of the signals of the source.

Also in accordance with one feature of the invention, a signal-translating system for a secrecy communication system comprises a source of signals to be translated, means for developing a random-frequency control potential, a signal-translating channel, and means coupled to the source and responsive to the control potential for applying to the channel signals of normal phase when the potential has a first value and for applying to the channel signals of opposite phase when the potential has a second value, whereby the intelligibility of the signals translated by the channel is modified.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

Referring now to the drawings, Fig. 1 is a circuit diagram, partly schematic, of a complete transmitter for a secrecy communication system embodying the invention; Figs. 2 and 3 are graphs used in explaining the operation of the invention; Fig. 4 is a circuit diagram, partly schematic, of a complete receiver for a secrecy communication system embodying the invention; Fig. 5 represents a modified form of signal source suitable for use in the transmitter of Fig. 1; Fig. 6 is a graph used in explaining the operation of the Fig. 5 arrangement; and Fig. 7 is a circuit diagram, partly schematic, representing a modified form of the signal-reproducing arrangement which is used at the receiver when the signal source of Fig. 5 is used at the transmitter.

Referring more particularly to Fig 1, there is represented schematically a complete carrier-signal transmitter of preferred form suitable for use in a secrecy communication system embodying the invention. The transmitter includes a source of audio-frequency signals to be transmitted, such as a microphone 10 coupled to the input of an audio-frequency amplifier 11. Also coupled to the input of the amplifier 11 through a switch 12 is a masking-tone generator 13 for generating oscillations of one or more frequencies suitably spaced over the speech-frequency range and serving as masking tones for the transmitted signals. The average amplitude of the oscillations generated by unit 13 may be suitably controlled in accordance with the average amplitude of the transmitted speech signals by a control system which is coupled through a switch 14 to the output circuit of the amplifier 11. Also coupled to the output circuit of the amplifier 11 is a conventional balanced modulator 15 having an output circuit coupled to a signal-translating channel 16, 17. The signal-translating channel includes a switch 18 having a first set of contacts 19 by which the channel may be coupled directly to the input of a modulator 20 and a second pair of contacts 21 by which the channel may alternatively be coupled to the input of the modulator 20 through a band-pass filter 22. The modulator 20 is also coupled to a carrier-signal oscillator 23. The output circuit of modulator 20 is coupled to the input circuit of a carrier-signal amplifier 24, the output circuit of which is coupled to an antenna system 25, 26.

The transmitter includes means for developing a random-frequency control potential comprising a cathode-ray tube 27 and a code card 28 which is positioned in front of the screen of the tube. The code card is generally opaque but has a plurality of apertures 28*a* aligned in parallel rows. A condensing lens system 29 is positioned to focus upon a photocell 30 light projected through the code card 28 from the fluorescent screen of the cathode-ray tube 27, thereby to develop in the output of the photocell a control potential of random frequency determined by the spacing and configuration of the apertures 28*a*. The cathode-ray beam of tube 27 is deflected in two directions normal to each other to form a predetermined pattern of scanning lines, corresponding to the aligned apertures 28*a* of the code card 28, by a scanning system comprising line-scanning and field-scanning windings 31, 32, respectively. The windings 31 and 32 are respectively energized by line-scanning and field-scanning generators included in a scanning generator and synchronizing system 33. An output circuit of the synchronizing system of unit 33 is coupled to the input of modulator 20 additionally to modulate the carrier-signal oscillations of unit 23 with synchronizing-signal components necessary to synchronize operation of the transmitter and receiver apparatus. The line-synchronizing signal component may be of sine wave form and the frame-synchronizing component may be a pulse used to modulate the line-frequency component, as by periodically deleting one half-cycle thereof at the time of the frame retrace. It will be pointed out in greater detail hereinafter that the preferred line-scanning and frame-scanning frequencies are 200 and 20 cycles, respectively. Such synchronizing components require a relatively narrow band to transmit the synchronizing information, for example, 200 to 400 cycles if only the upper sideband of the

200-cycle carrier is used, and thus lie below the range of speech frequencies utilized and may be transmitted continuously without interfering with the transmission and reproduction of the speech signals. The photocell 30 is coupled to the input circuit of a phase inverter 34, the output circuit of which is coupled in push-pull relation to the input circuit of the balanced modulator 15.

In considering the operation of the circuit just described, it will be assumed that switches 12 and 14 are open and that switch 18 is operated to connect the signal-translating channel 16, 17 directly to the input circuit of modulator 20 through the contacts 19. Referring to the curves of Fig. 2, curve A represents a speech signal generated by the microphone 10 and which it is desired to transmit. The speech signal is applied to the amplifier 11 where it is amplified and applied to the input circuit of the balanced modulator 15. As the cathode-ray beam of tube 27 scans parallel lines corresponding to the aligned apertures 28*a* of the code card 28, the light from the illuminated fluorescent screen of tube 27 is projected through the apertures 28*a* of the code card 28 and is focused by the lens system 29 upon the photocell 30. There is thus developed in the output of the photocell 30 a random-frequency control potential having a rectangular pulse wave form of constant amplitude, as represented by curve B. Either the number of apertures 28*a* in each line, or the configuration of the apertures, or both, is so proportioned that the fundamental frequencies of the control potential developed by the photocell 30, that is, the frequencies of occurrence of the pulses, lie in a frequency range preferably slightly above the range of speech frequencies selected as satisfactory for speech intelligibility.

Since the random-frequency control potential is applied through the phase inverter 34 in push-pull relation to the input circuit of the balanced modulator 15, the gains of the repeater vacuum tubes conventionally included in unit 15 are changed in inverse sense in accordance with the value of the control potential. That is, if it be assumed for simplicity that each of the repeater vacuum tubes of unit 15 is normally biased to cut-off, the control potential causes one repeater vacuum tube to be conductive when the control potential has a first value, as the value e, and alternately causes the other repeater vacuum tube to be conductive when the control potential has a second value e_1. The signal applied to the input circuit of the balanced modulator 15 is thus applied to the signal channel 16, 17 in normal phase, as during the intervals t_1—t_2, t_3—t_4, etc., when the one repeater vacuum tube is conductive due to the control potential e and is applied to the signal channel in opposite phase when the second repeater vacuum tube is conductive, as during the intervals t_2—t_3, t_4—t_5, etc., when the control potential has the second value e_1. The signal thus applied to the control channel 16, 17 is of mutilated wave form, as represented by curve C, and would not be intelligible if reproduced by conventional reproducing apparatus.

The signal of mutilated wave form applied to the signal-translating channel 16, 17 is applied to the input of modulator 20, together with synchronizing-signal components from unit 33, to modulate in conventional manner the carrier signal generated by unit 23. The modulated oscillations are subsequently amplified by the carrier-signal amplifier 24 and are transmitted by the antenna system 25, 26.

In the above-described operation of the invention, it was stated that the random-frequency control potential preferably had fundamental frequencies lying above a selected range of speech frequencies. Thus, if the range of speech frequencies necessary for satisfactory intelligibility be considered as including the range from 0.5 to 2.5 kilocycles, as represented by curve D of Fig. 3, the control potential of random frequency preferably includes a fundamental frequency range extending from 2.5 to 3.5 kilocycles as represented by curve E. From another viewpoint, the modulator 15 effectively mixes the speech signals and the random-frequency control potential to produce a lower sideband extending from 0 to 3.0 kilocycles and an upper sideband which, considering only the fundamental frequency components of the control potential, extends from 3.0 to 6.0 kilocycles, as indicated by the respective solid and broken line curves F of Fig. 3. The value of this sideband analysis of the operation of the Fig. 1 arrangement will become more apparent hereinafter when a modified type of operation involving the band-pass filter 22 is considered.

A control potential of a random frequency such as shown by curve B of Fig. 2 may be derived by providing ten aligned rows of apertures 28*a* in the code card 28 and by causing the cathode-ray beam of tube 27 completely to scan the code card 28 twenty times per second. The line frequency of the scanning system is then 200 cycles per second and the frame frequency is 20 cycles per second. Since the desired mean frequency of the control potential for the case here assumed is 3.0 kilocycles, there would be an average of fifteen apertures 28*a*, or thirty elements comprising fifteen opaque and fifteen transparent elements, in each row. The required maximum frequency deviation of 0.5 kilocycle above and below the mean frequency of 3.0 kilocycles may be obtained by the method of increasing or decreasing the number of elements in the several rows. That is, the addition of elements to or the subtraction of elements from, each row increases or decreases the frequency of the control potential by a deviation of 500 cycles. Thus, by suitably varying the number of elements in the row, the random frequency of the control potential may be varied within a range extending from 2.5 to 3.5 kilocycles.

Alternatively required frequency deviations of the control potential may be obtained by the method of maintaining equal numbers of apertures in each line but suitably changing the lengths of the apertures in the direction of their alignment, as indicated schematically in Fig. 1 in which, for the sake of clarity, the number of apertures and scanning lines has been reduced. A sufficiently large number of changeable code cards may be thus provided to insure a high probability of secrecy of communication. The code cards are preferably printed on strong photographic film, as in lengths of film of 35 mm. width. This has the advantage that several hundred such code cards may be printed on a single strip of film, thereby to facilitate transportation and distribution.

The secrecy of communication may be improved by operation of the switch 18 to close its contacts 21, whereby the output circuit of the balanced modulator 15 is coupled through the band-pass filter 22 to the input circuit of the modulator 20. The band-pass filter 22 has a pass band sufficient only to pass the useful portion of the lower sideband of the modulation components appearing in the output of the balanced modulator 15, preferably the portion of the lower sideband extending from 0.5 to 2.5 kilocycles, as indicated by curve G of Fig. 3, the speech frequencies of the lower sideband being inverted with respect to the original signal as indicated by the arrow applied to curve G. It will be noted that by this selection of only a portion of the lower sideband, energy produced by speech components between 1000 and 2000 cycles is transmitted all of the time, while that due to the 500 to 1000 cycle and 2000 to 2500 cycle bands is transmitted alternately, as indicated by the shaded areas of curve G, depending upon whether the random-frequency control potential has an instantaneous value of frequency above or below 3 kilocycles. This arrangement permits full use of the transmitting channel spectrum while the output has an effective band width of about 750 to 2250 cycles.

The transmission of a single sideband in the manner just described has the slight disadvantage, however, that the requirement regarding the reinsertion of a random-frequency control potential to restore intelligibility of the speech is not as rigid as where both sidebands are transmitted, the tolerance in the frequency of the control potential being about ±500 cycles to produce understandable speech in single sideband transmission, as compared to about ±100 cycles with double sideband transmission. This slight disadvantage may be avoided by the use of the masking-tone generator 13. Thus when the switch 12 is closed, one or more constant frequency tones are applied to the input circuit of the amplifier 11 and are combined with the speech signal in the output circuit of this amplifier. One of the masking tones should have a frequency at about the middle of the range of speech frequencies, for example, 1.5 kilocycles. When the random-frequency control potential at the receiver, presently to be described, has the same wave form as, and is synchronous with, that developed by the photocell 30, the masking tone or tones can be selected out by sharply-tuned rejector filters without any appreciable effect upon the reproduced speech. When, however, the random-frequency control potential at the receiver does not accurately correspond to that at the transmitter, as when an unauthorized listener is attempting by the method of trial and error to restore intelligibility of the communication, the masking tone or tones effectively become a noise which produces a masking effect upon any small amount of intelligibility that would otherwise be obtained.

When using masking tones in the manner described, they should not be allowed to continue during the intervals between speech since they represent information from which the character of the random-frequency control potential can be deduced. It is thus preferable to use a voice-operated relay or a "press-to-talk" switch for silencing either the masking-tone generator 13 or one of the units 20 or 24 during the intervals between speech. A voice-operated relay is preferably employed in unit 13 and is arranged to become operative upon closure of switch 14 to connect the relay in suitable manner to the output circuit of the amplifier 11. The masking tones of unit 13 can also be used to mask the syllabic content of speech. The average amplitude of the speech signal is obtained by suitable rectification and is utilized to vary the amplitude of the masking tones inversely in accordance with the average amplitude of the speech signal, so that the total speech signal and masking tone output from the speech amplifier 11 is of approximately constant amplitude.

From the above-described operation of the Fig. 1 arrangement, it will be evident that the balanced modulator 15 comprises means coupled to the source of signals 10 and responsive to the random-frequency control potential developed by the photocell 30 for applying to the signal channel 16, 17 signals of normal phase when the control potential has a first value and for applying to the signal channel signals of opposite phase when the control potential has a second value, whereby the signals translated by the channel have mutilated wave form and would not be intelligible if reproduced in conventional manner. Also, the phase inverter 34 comprises means for applying the random-frequency control potential developed by photocell 30 to the modulating means to develop in the signal channel 16, 17 random-frequency modulation sidebands, as those indicated by curve F of Fig. 3.

Fig. 4 schematically represents a carrier-signal receiver suitable for use with a transmitter of the type shown in Fig. 1 in a secrecy communication system embodying the invention. The receiver includes a radio-frequency amplifier 35 having an input circuit coupled to an antenna system 36, 37. Coupled to the output circuit of the radio-frequency amplifier 35, in the order named, are a detector and synchronizing-signal separator 38 and a balanced modulator 39. The output circuit of the balanced modulator 39 is coupled through a first pair of contacts 41 of switch 40 directly to the input of an audio-frequency amplifier 42 or through a second pair of switch contacts 43 and through a masking-tone filter 44 to the input circuit of amplifier 42. The output circuit of the audio-frequency amplifier 42 is coupled to a signal-reproducing device 45, for example, a loudspeaker. The receiver includes means for developing a second random-frequency control potential having the same wave form as, and substantially synchronous with, the first random-frequency control potential developed at the transmitter, this means comprising a cathode-ray tube 46, a code card 47, condensing lens system 48, and photocell 49, identical with, and arranged in the same manner as, the corresponding elements of the transmitter. The cathode-ray beam of tube 46 is deflected in two directions normal to each other by line-deflecting and field-deflecting windings 50, 51, respectively, which are energized by suitable line-scanning and field-scanning generators 52. The scanning generators of unit 52 are operated in synchronism with the corresponding generators of the transmitter, except, of course, for the infinitesimally small time delay required for the carrier signal with its speech-frequency and synchronizing-modulation components to travel through space from the transmitter to the receiver, by separating from the transmitted carrier signal in the unit 38 the synchronizing-signal components which, after proper separation from each other, are applied to synchronizing circuits of the scanning generators of unit 52. A random-frequency control potential is developed in the output circuit of the photocell 49, in a manner identical to the development of the corresponding random-frequency control potential at the transmitter and is applied through a phase inverter 53 to the input of the balanced modulator 39.

In considering the operation of the receiver above described, it will be assumed that either the single or double sideband method of speech transmission is employed at the transmitter and that no masking tones are transmitted. In this event, the switch 40 is operated to close its contacts 41, whereby the balanced modulator 39 is coupled directly to the input circuit of the audio-frequency amplifier 42. The synchronizing-signal components of the received carrier signal are separated therefrom by the synchronizing-signal separator of unit 38 and are applied to the scanning generators 52 to synchronize their operation with the corresponding units at the transmitter. The cathode-ray beam of tube 46 consequently moves in synchronism with the cathode-ray beam of the corresponding tube of the transmitter and there is developed by the photocell 49 a random-frequency control potential having the same wave form as, and substantially synchronous with, the random-frequency control potential developed at the transmitter. This control potential thus has the wave form represented by curve B of Fig. 2 and is applied through the phase inverter 53 in push-pull relation to the input circuit of the balanced modulator 39.

The received carrier signal after amplification by unit 35 is detected by the detector of unit 38 to derive the speech-frequency modulation components of the carrier signal, these components having a wave form as represented by curve C of Fig. 2. The modulation-frequency components are applied from the detector of unit 38 in push-pull relation to the vacuum tubes of the balanced modulator 39. The balanced modulator 39 operates in similar fashion to that of the corresponding unit of the transmitter and applies to the audio-frequency amplifier 42 and signal-reproducing device 45 signals of one phase when the control potential developed by photocell 49 has a first value and signals of opposite phase when the control potential has a second value, thus performing an operation on the speech-frequency components inverse to that performed at the transmitter, whereby the signal applied to the unit 42 and reproducing device 45 has a wave form as represented by curve A of Fig. 2. This is the original wave form of the speech signals developed by the microphone 10 of the transmitter. The signals applied to the sound-reproducing device 45 are reproduced thereby with substantially the full intelligibility of the original signals.

In the event that masking tones are superimposed upon the speech frequencies before transmission, in the manner explained above, the switch 40 is operated to close its contacts 43, whereby the output circuit of the balanced modulator 39 is coupled through the masking-tone filter 44 to the input circuit of the audio-frequency amplifier 42. The masking-tone filter 44 includes one or more very narrow band-rejector filters, each tuned to an individual one of the masking tones. The masking tones are thus removed by unit 44 from the speech-frequency components of the carrier signal and consequently are not applied to the audio-frequency amplifier 42 and are not reproduced by the signal-reproducing device 45. In the event that the amplitude of the masking tones is varied at the transmitter in accordance with the average amplitude of the speech signals to be transmitted, the band-pass selectors of unit 44 have wider pass bands, since the masking tones now have low-frequency sidebands.

Fig. 5 is a circuit diagram representing a modified form of signal source which is suitable for use in a secrecy communication system embodying the invention in the event that it is desired to transmit keyed signals instead of speech signals, the source being suitably substituted for the units 10-13, inclusive, of Fig. 1 by connection of the terminals A, B, C to corresponding terminals of modulator 15. In this arrangement, a manually operable key 59 is connected through a battery 60 to the operating winding 61 of a relay 62. The relay 62 includes a pair of movable contact arms 63, 64 which are normally biased to close a pair of respective contacts 65, 66, but which, upon energization of the relay, move to close a second pair of respective contacts 67, 68. A battery 69 is connected through relay arms 63 and 64 and normally closed contacts 65, 66, respectively, to apply a bias of one polarity to one of the repeater vacuum tubes of unit 15, Fig. 1, and opposite polarity to the other repeater vacuum tube of this unit, the polarity applied to each tube being reversed upon movement of the relay arms 63, 64 to close the respective relay contacts 67, 68.

Considering now the operation of the Fig. 5 arrangement, and referring to the curves of Fig. 6, curve D represents the desired signal to be transmitted and which is produced with opposite polarities between terminals A—B and B—C upon manual operation of key 59. This signal is applied to the input of the balanced modulator 15. There is also applied to the input of the balanced modulator 15 through the phase inverter 34 a random-frequency control potential, as represented by curve E. The control potential so controls the operation of the balanced modulator 15, as explained above, that there is applied to the signal channel 16, 17 signals of normal phase when the control potential has a first value and opposite phase when the control potential has a second value, as represented by curve F, this operation being the same as that described above in connection with speech signals.

When the keying arrangement of Fig. 5 is utilized at the transmitter, the signal-reproducing device 45 of the receiver arrangement of Fig. 4 is replaced by the signal-reproducing system of Fig. 7 by connection of the terminals X, X to corresponding terminals of amplifier 42 of Fig. 4. The latter arrangement includes a relay 70 having its operating winding coupled across the output of the audio-frequency amplifier 42. The audio-frequency amplifier 42 in this case is a direct current amplifier in order that the direct current component of the keying signal shall not be lost by translation of the signal through the amplifier. The relay 70 is provided with a pair of relay contact arms 71, 72, which are coupled to the output of an audio-frequency oscillator 73, and normally open switch contacts 74, 75 which are coupled to a signal-reproducing device 76, for example, a pair of headphones. A receiver embodying the signal-reproducing system of Fig. 7 operates in general, as described above in connection with the arrangement of Fig. 4, to derive the modulation components of the received carrier signal, represented by curve F of Fig. 6, and to combine therewith a random-frequency potential having the wave form represented by curve E, Fig. 6, which is identical to that of the corresponding control potential at the transmitter, thereby to derive the original keying signal represented by curve D of Fig. 6. The keying signal is applied to the relay 70 to close the relay contacts 74, 75 during each pulse of the signal, thereby to apply a keyed audible tone from unit 73 to the signal-reproducing device 76.

From the above description of the invention, it will be evident that a secrecy communication system embodying the invention has the advantages of simplicity of construction and a high degree of reliability of operation. There is the additional advantage that the code cards, which determine the manner of operation and which make it substantially impossible for an unauthorized person to restore the intelligibility of the transmitted signal, may be easily and rapidly duplicated on photographic film by well-known printing processes, and a large number of such code cards, for example, 500 or 1000, may be printed in prearranged order in compact form for ready distribution as a continuous strip of film. In using this secrecy communication system, it is preferable that the code cards be changed in prearranged order at rather frequent intervals, thus making it practically impossible for an unauthorized listener by trial and error to restore intelligibility of the communication even though he possesses a complete receiving apparatus and a complete set of code cards in current use.

While there have been described what are at present considered to be the preferred embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A secrecy communication system comprising, a source of signals to be transmitted, means for developing a random-frequency control potential, a signal-translating channel, means coupled to said source and responsive to said control potential for applying to said channel signals of normal phase when said potential has a first value and for applying to said channel signals of opposite phase when said potential has a second value, whereby the signals translated by said channel have mutilated wave form and would not be intelligible if reproduced, means for developing a second random-frequency control potential having the same wave form as and substantially synchronous with said first control potential, a signal-reproducing device, and means adapted to have applied thereto signals translated by said channel and responsive to said second control potential for applying to said device translated signals of one phase when said second potential has a first value and for applying to said device translated signals of opposite phase when said second potential has a second value, whereby the signals applied to said device are reproduced thereby with substantially the full intelligibility of the signals of said source.

2. In a secrecy communication system, a signal-translating system comprising, a source of signals to be translated, means for developing a random-frequency control potential, a signal-translating channel, and means coupled to said source and responsive to said control potential for applying to said channel signals of normal phase when said potential has a first value and for applying to said channel signals of opposite phase when said potential has a second value, whereby the intelligibility of the signals translated by said channel is modified.

3. In a secrecy communication system, a signal-translating system comprising, a source of signals to be translated, means for developing a random-frequency control potential, the mean fundamental frequency of said control potential being above the range of frequencies of said signals to be utilized, a signal-translating channel, and means coupled to said source and responsive to said control potential for applying to said channel signals of normal phase when said potential has a first value and for applying to said channel signals of opposite phase when said potential has a second value, whereby the intelligibility of the signals translated by said channel is modified.

4. In a secrecy communication system, a signal-translating system comprising, a source of signals to be translated, means for developing a random-frequency control potential having a fundamental frequency deviation range above the range of frequencies of said signals to be utilized, a signal-translating channel, and means coupled to said source and responsive to said control potential for applying to said channel signals of normal phase when said potential has a first value and for applying to said channel signals of opposite phase when said potential has a second value, whereby the intelligibility of the signals translated by said channel is modified.

5. In a secrecy communication system, a signal-translating system comprising, a source of signals to be translated, means for developing a random-frequency control potential of substantially constant amplitude, a signal-translating channel, and means coupled to said source and responsive to said control potential for applying to said channel signals of normal phase when said potential has a first value and for applying to said channel signals of opposite phase when said potential has a second value, whereby the intelligibility of the signals translated by said channel is modified.

6. In a secrecy communication system, a signal-translating system comprising, a source of signals to be translated, means for developing a random-frequency control potential of substantially rectangular pulse wave form, a signal-translating channel, and means coupled to said source and responsive to said control potential for applying to said channel signals of normal phase when said potential has a first value and for applying to said channel signals of opposite phase when said potential has a second value, whereby the intelligibility of the signals translated by said channel is modified.

7. In a secrecy communication system, a signal-translating system comprising, a source of signals to be translated, means for developing a random-frequency control potential, a signal-translating channel, modulating means coupled between said source and said channel, and means for applying said control potential to said modulating means to develop in said channel random-frequency modulation sidebands, whereby the intelligibility of the signals translated by said channel is modified.

8. In a secrecy communication system, a signal transmitter comprising, a source of signals to be transmitted, means for developing a random-frequency control potential, a signal-translating channel, and means coupled to said source and responsive to said control potential for applying to said channel signals of normal phase when said potential has a first value and for applying to said channel signals of opposite phase when

said potential has a second value, whereby the signals translated by said channel have mutilated wave form and would not be intelligible if reproduced.

9. In a secrecy communication system, a signal-translating system comprising, a source of signals to be translated, a cathode-ray tube having a fluorescent screen, a photoelectric cell, a code card adapted to be positioned between said screen and said photoelectric cell and having a predetermined pattern of apertures, means for deflecting the cathode-ray beam of said tube to scan said screen in a predetermined scanning pattern corresponding to the pattern of said code card apertures to develop in the output circuit of said photocell a random-frequency control potential, a signal-translating channel, and means coupled to said source and responsive to said control potential for applying to said channel signals of normal phase when said potential has a first value and for applying to said channel signals of opposite phase when said potential has a second value, whereby the intelligibility of the signals translated by said channel is modified.

10. In a secrecy communication system, a signal-translating system comprising, a source of signals to be translated, a cathode-ray tube having a fluorescent screen, a photoelectric cell, a code card adapted to be positioned between said screen and said photoelectric cell and having a predetermined pattern of apertures aligned in parallel rows, means for deflecting the cathode-ray beam of said tube to scan said screen in a predetermined scanning patttern of parallel lines corresponding to the aligned rows of apertures of said code card to develop in the output circuit of said photocell a random-frequency control potential, a signal-translating channel, and means coupled to said source and responsive to said control potential for applying to said channel signals of normal phase when said potential has a first value and for applying to said channel signals of opposite phase when said potential has a second value, whereby the intelligibility of the signals translated by said channel is modified.

11. In a secrecy communication system, a signal-transmitter comprising, a source of signals to be transmitted, a cathode-ray tube having a fluorescent screen, a photoelectric cell, a code card adapted to be positioned between said screen and said photoelectric cell and having a predetermined pattern of apertures, means for deflecting the cathode-ray beam of said tube to scan said screen in a predetermined pattern corresponding to the pattern of said code card apertures to develop in the output circuit of said photocell a random-frequency control potential, a signal-translating channel, means coupled to said source and responsive to said control potential for applying to said channel signals of normal phase when said potential has a first value and for applying to said channel signals of opposite phase when said potential has a second value, whereby the intelligibility of the signals translated by said channel is modified, and means for combining with said translated signals synchronizing signals derived from said deflecting means to synchronize the operation of a signal receiver having a similar cathode-ray tube type of random-frequency control potential generator.

12. In a secrecy communication system, a signal receiver comprising, modulating means adapted to have applied thereto received signals the phase of which is alternately normal and reversed in accordance with two values of a random-frequency control potential, means for locally developing a random-frequency control potential having the same wave form as and substantially synchronous with said random-frequency control potential, a signal-reproducing device coupled to said modulating means, and means for controlling said modulating means by said control potential to apply to said device received signals of one phase when said control potential has a first value and for applying to said device received signals of opposite phase when said control potential has a second value, whereby signals applied to said device are reproduced thereby with substantially the full intelligibility of the original signals.

13. A secrecy communication system comprising, an input circuit adapted to have applied thereto a speech signal to be transmitted, means for displacing said speech signal in the frequency spectrum by predetermined values in a predetermined random order of such values at intervals not substantially longer than 50 milliseconds, means for translating and receiving said displaced speech signal and for deriving therefrom said first-named signal, and means for utilizing said last-named derived signal.

14. A secrecy communication system comprising, an input circuit adapted to have applied thereto a speech signal to be transmitted, electronic switching means for displacing said speech signal in the frequency spectrum by predetermined values and in a predetermined random order of such values at intervals not substantially longer than 50 milliseconds, means for translating and receiving said displaced speech signal and for deriving therefrom said first-named signal, and means for utilizing said last-named derived signal.

15. A secrecy communication system comprising, an input circuit adapted to have applied thereto a speech signal to be transmitted, modulating means coupled to said input circuit for translating said speech signal, means for developing a random-frequency control potential, and means for applying said control potential to said modulating means for displacing said speech signal in the frequency spectrum by predetermined values and in a predetermined random order of such values at intervals not substantially longer than 50 milliseconds, whereby the intelligibility of the signals translated by said modulating means is modified.

16. A secrecy communication system comprising, an input circuit adapted to have applied thereto a speech signal to be transmitted, modulating means coupled to said input circuit for translating said speech signal, photo-electronic means for developing a random-frequency control potential, and means for applying said control potential to said modulating means for displacing said speech signal in the frequency spectrum by predetermined values and in a predetermined random order of such values at intervals not substantially longer than 50 milliseconds, whereby the intelligibility of the signals translated by said modulating means is modified.

17. A secrecy communication system comprising, an input circuit adapted to have applied thereto a speech signal to be transmitted, modulating means coupled to said input circuit for translating said speech signal, means for developing a random-frequency control potential, said last-named means including a code card for determining the random frequency of said control potential, and means for applying said control

potential to said modulating means for displacing said speech signal in the frequency spectrum by predetermined values and in a predetermined random order of such values at intervals not substantially longer than 50 milliseconds, whereby the intelligibility of the signals translated by said modulating means is modified.

18. A secrecy communication system comprising, an input circuit adapted to have applied thereto a speech signal to be transmitted, modulating means coupled to said input circuit for translating said speech signal, means for developing a random-frequency control potential including means for determining the random frequency of said control potential in accordance with a predetermined plan of transmission, and means for applying said control potential to said modulating means for displacing said speech signal in the frequency spectrum by predetermined values and in a predetermined random order of such values at intervals not substantially longer than 50 milliseconds, whereby the intelligibility of the signal translated by said modulating means is modified.

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