Feb. 26, 1946. R. M. SPRAGUE 2,395,431

SECRECY SIGNALING SYSTEM, METHOD, AND APPARATUS

Filed Sept. 11, 1941 4 Sheets-Sheet 1

Fig. 1A.

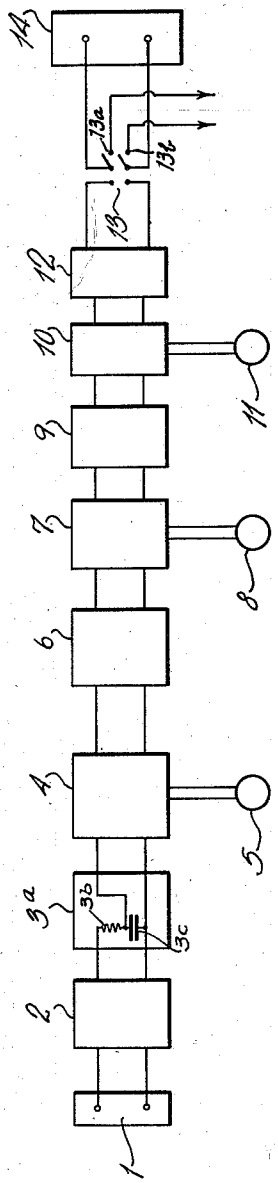
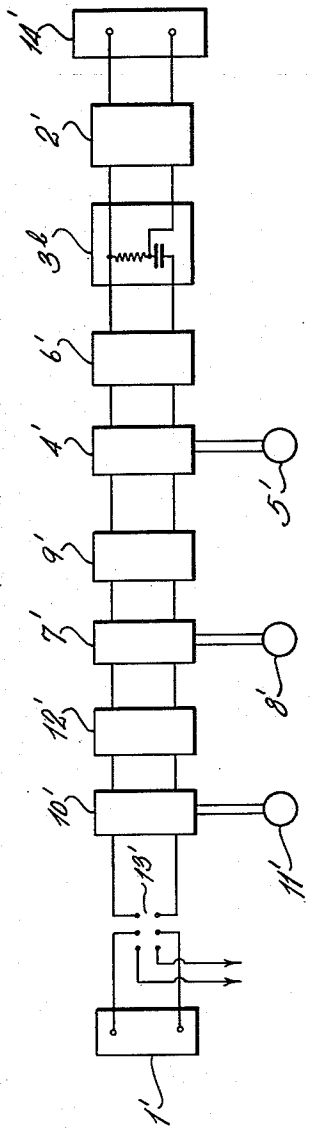


Fig. 1B.



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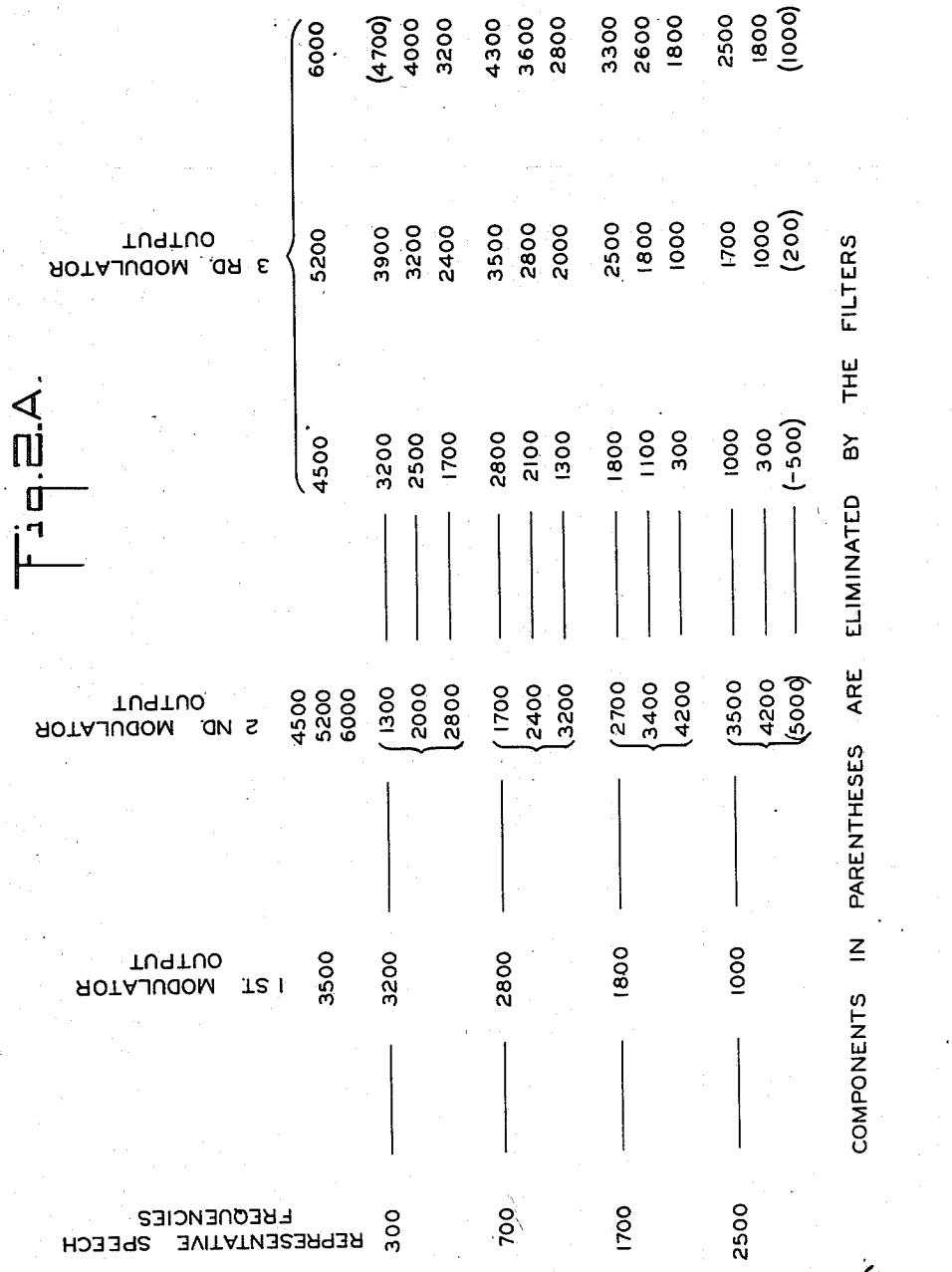
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Feb. 26, 1946. R. M. SPRAGUE 2,395,431

SECRECY SIGNALING SYSTEM, METHOD, AND APPARATUS

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Fig. 2A.



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SECRECY SIGNALING SYSTEM, METHOD, AND APPARATUS

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Fig. 2.B.

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SECRECY SIGNALING SYSTEM, METHOD, AND APPARATUS

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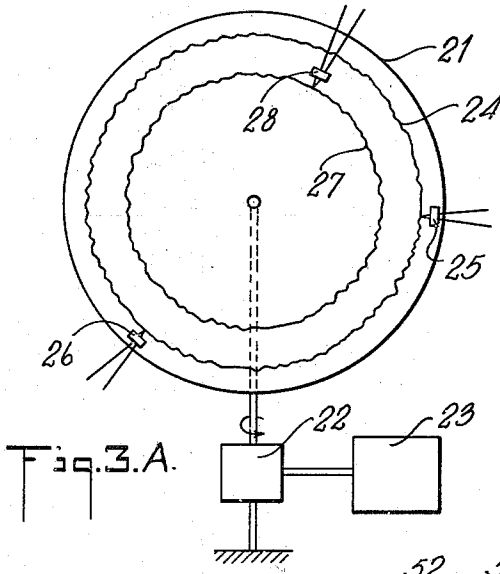


Fig. 3. A.

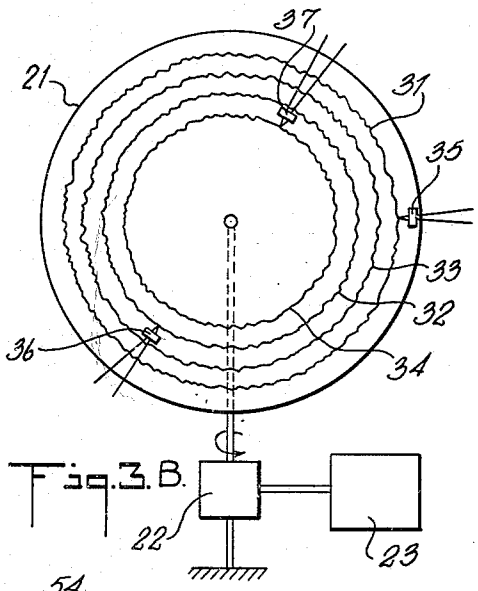


Fig. 3. B.

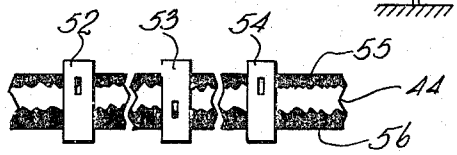


Fig. 3. E.

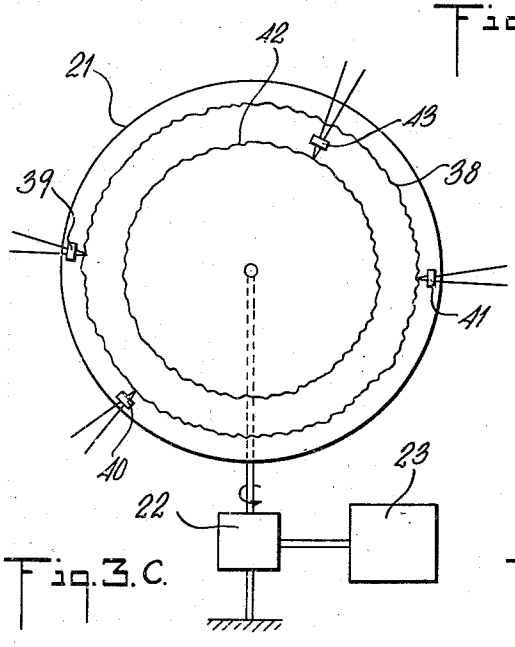


Fig. 3. C.

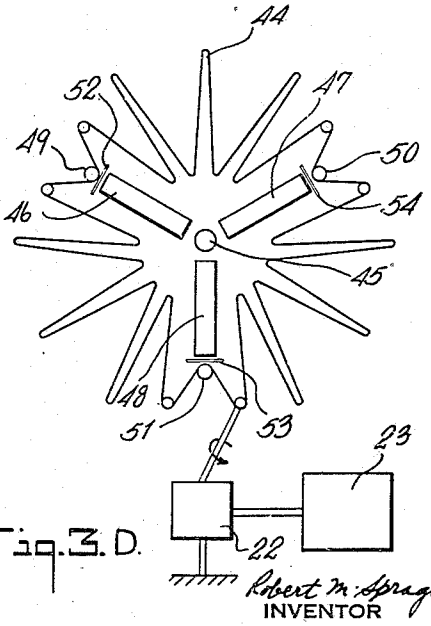


Fig. 3. D.

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Patented Feb. 26, 1946 2,395,431

UNITED STATES PATENT OFFICE

2,395,431

SECRECY SIGNALING SYSTEM, METHOD, AND APPARATUS

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Application September 11, 1941, Serial No. 410,450

41 Claims. (Cl. 179—1.5)

This invention relates to the secret transmission of intelligence and more particularly to the secret transmission of intelligence by audio frequency signals such as speech signals and the like.

A principal object of the invention is to provide a method and apparatus for secret transmission and reception of intelligence employing coding arrangements in the form of variable carriers of haphazard or arbitrary frequency succession.

Another object is to provide a method and apparatus for secret signaling whereby the possibility of unauthorized detection can be decreased to any desired extent without employing correspondingly complicated mechanical or electrical devices.

Another object is to provide a system of secret signaling wherein phonographic or similar haphazard carrier frequency coding members are employed at the transmitter and receiver, in conjunction with wave modulating arrangements whereby the coding can be changed at any desired time, for example between transmission of portions of a message or between complete messages.

A feature of the invention relates to a secret signaling system wherein a carrier generator or a series of carrier generators of variable haphazard or arbitrary frequency are employed at a transmitter, and a similar generator or series of generators are employed at the receiver, in conjunction with special synchronizing "framing" arrangements whereby the possibility of unauthorized interception is rendered practically unattainable.

A further feature relates to a method of secret signaling wherein a plurality of successive stages of carrier modulation are employed at a transmitter and at a receiver with the carrier frequencies of each stage varying from instant to instant at a haphazard or arbitrary rate, and with the successive stages non-synchronous as to instantaneous carrier frequency while the corresponding stages at the transmitter and receiver respectively are synchronized.

A further feature relates to a novel modulation arrangement for use in secret signaling systems.

A still further feature relates to the novel organization, arrangement and relative interconnection of parts whereby a comparatively simple and highly unbreakable coding arrangement is provided for secret signaling systems.

Other features and advantages not specifically enumerated will be apparent after a consideration of the following detailed descriptions and the appended claims.

While the invention finds its primary utility in the transmission of intelligence represented by speech signals, it will be understood of course that the invention is equally applicable to analogous systems wherein the signals are represented by audio frequency waves or variations. Accordingly in the drawings,

Fig. 1A is a block diagram of a preferred arrangement of modulators and related apparatus to effect the secret coding or scrambling according to the invention.

Fig. 1B is a block diagram of the corresponding preferred arrangement of modulators and related apparatus to effect the coding or unscrambling at a receiving station.

Fig. 2A is a tabulation of the frequencies to which typical voice frequencies are changed by successive modulations according to the invention.

Fig. 2B is the converse of Fig. 2A, showing the return of the scrambled speech frequencies to their correct frequencies by the receiver arrangement of Fig. 1B.

Fig. 3A is a schematic diagram of one arrangement for supplying the varying carrier frequencies for the modulators and for supplying the framing signals for the transmitter and receiver of Figs. 1A and 1B respectively.

Figs. 3B, 3C and 3D represent respectively three modifications of the mechanism of Fig. 3A.

All previous types of speech secrecy systems possess several inherent disadvantages. Some are really only privacy systems which serve merely to delay decoding of the intelligence. Some systems are too complicated and too bulky for any but large fixed station installations. Some use a masking signal which greatly reduces the efficiency of a radio telephone transmitter. Some require definite time for decoding or translation of the intelligence. Others are secret until a none too complicated key has been discovered, from which point any succeeding intelligence can be easily understood. Many others have only a finite number of keys, so once all keys are discovered, the entire equipment is rendered useless. In the following description it will appear that my system possesses none of these disadvantages but has all desired advantages in that it is simple, light of weight, easy to adjust and operate, affords direct two or more way communication, is 100% secretive, and is adaptable to any normal wire or radio telephone installation.

This system is based on the principle of mul-

tiple continuously haphazardly varying scrambling at the transmitting end with simultaneous identical unscrambling at the receiving end. This is accomplished by means of identical scramblers and unscramblers running in synchronism with each other. Scrambling is accomplished by progressive intermodulation of the voice frequencies and several continuously haphazardly varying carriers and selecting the resultant difference or sum frequencies. The carrier frequencies are continuously changing and not jumping step by step, so any slight drift from true synchronism between transmitter and receiver results only in "squeaky" understandable speech which is easily corrected, and not in short periods where speech is totally incoherent. Any number of such successive modulations, using a different carrier each time, may be used. Phasing and drift from synchronism are accounted for in a unique manner, and are described hereinbelow.

Referring to Fig. 1A, the speech signals which have been translated into corresponding electric currents by any well-known pick-up and amplifier device, are passed through a low-pass filter unit 2 to limit the upper frequency of the voice frequency signals to 2500 cycles. These signals are then passed through a distorter 3A which consists of suitable electrical circuit elements represented schematically by the resistor 3B and condenser 3C designed to give an output response proportional to frequency of input signals. This tends to equalize the fundamental and harmonic components of the speech signals, thereby making the unauthorized resolution of the final signal into its component frequencies still more difficult, and also enabling more efficient use of the modulators. The distorted speech signals are then fed to the double balanced modulator 4 which is supplied with a fixed carrier frequency from a suitable source 5. Preferably the source 5 is of an audio frequency above 2500, e. g., 3500 C. P. S. For a detailed description of such a typical modulator 4, reference may be had to "Bell System Technical Journal" for April 1939, page 318, Figure 2c. As is well-known, this type of modulator passes mainly to its output circuit only the sum and difference frequencies between the frequency of the source 5 and the frequencies of the input signals passed by the device 3A. The sum and difference frequencies from the modulator 4 are applied to a filter 6 which passes only the difference components, although if desired, the filter 6 may be designed to pass only the "sum" components. If the difference frequencies are passed, they are then fed into a second double balanced modulator 7 which may be similar to the modulator 4 but is supplied with a carrier frequency from the source 8 which frequency varies from instant to instant in a non-regular arbitrary or haphazard manner and rate. For example, the source 8 may generate frequencies in the band between 4500 and 6000 C. P. S., the frequency succession being determined by mechanism which will be described hereinbelow in connection with Figs. 3A to 3D.

The output of the balanced modulator 7 is then passed through a filter 9 which is designed to pass only the "difference" frequencies between the source 8 and the device 6. The resultant signal is then fed into a still another double balanced modulator 10 similar to modulators 4 and 7. Modulator 10 is supplied with variable frequency carrier from source 11, the frequency succession of which differs from the frequency succession of the carriers from source 8 although the band of frequencies from source 11 may be the same as the band from source 8, e. g., 4500 to 6000 C. P. S. The sum and difference frequencies in the output of device 10 are passed through a filter 12 to suppress all except the difference frequencies. These difference frequencies are then connected to the contacts of the double pole double throw switch 13, the movable contacts of which are connected to a suitable output terminal network 14 whereby they may be transmitted over a wire or radio link.

While in Fig. 1A the signals are subjected to two stages of variable carrier modulation, i. e., stages 7 and 10, it will be understood that a greater number of similar modulating stages may be employed to afford further coding or scrambling combinations as described hereinbelow. In any event, the additional stages while they may supply carrier frequencies within the same band as those of sources 8 and 11, have a different frequency succession as compared with the said sources so that no two succeeding modulators have the same variation of frequency with time so far as the supply of carrier thereto is concerned. It will be understood of course that wherever required, amplifying stages and other related apparatus not necessary to an understanding of the invention may be supplied, these additional components being omitted from the drawings for the purpose of clarity. It will be understood also that instead of selecting the "difference" frequencies from the respective modulators or the "sum" frequencies from these modulators, any combination of sum and difference frequencies may be selected.

At the receiving terminal or station, an analogous system of plural variable carrier modulation or demodulation is employed except that the succession of carriers with respect to the successive stages is reversed as compared with the transmitter. For purposes of simplicity, parts of the apparatus of Fig. 1B which correspond to the apparatus of Fig. 1A, bear the same designation numerals primed. Thus, in Fig. 1B the scrambled signals from the transmitter are passed to a suitable detecting or amplifying device 1', the output of which is connected to a two-position switch 13' and one set of fixed terminals of switch 13' are connected to the double balanced modulator 10' which is supplied with variable carrier frequency from the source 11'. Under the frequency conditions above assumed, the carriers from source 11' will occupy the same frequency band as those from source 11 and will be synchronzed therewith so as to have the same successions of frequency with respect to time. The sum and difference frequencies between the input signals in device 10' and the carrier frequencies from source 11' are impressed upon filter 12' which passes only the difference frequencies. The difference frequencies are then impressed upon a double balanced modulator 7' which is supplied with variable carrier frequencies from source 8', source 8' being synchronized with the source 8 at the transmitter so as to produce the same frequency successions with respect to time. The difference frequencies in the output of modulator 7' are passed by the filter 9' and are then impressed upon the balanced modulator 4' which is supplied with a fixed carrier frequency from the source 5', the source 5' has the same frequency as the source 5. The difference frequencies in the output of modulator 4' are passed by filter 6' and are then impressed upon the "restorer" 3B which is designed to be the converse of the distorter 3A at the transmitter so as

to restore the original relation between the fundamental and harmonic components of the speech signals. The restored signals are, if desired, passed through the filter 2' so as to eliminate any undesired components above 2500 C. P. S. These signals are then reproduced in any suitable voice frequency reproducer 14' or they may be retransmitted over a transmission system similar to that of Fig. 1A.

Fig. 2A is a chart showing several representative frequencies out of the speech spectrum between 300 and 2500 cycles and the frequencies that these combinations assume upon each succeeding modulation. In this example the carrier from source 5 was 3500 cycles, while the carrier from source 8 was varying between 4500 and 6000 as was also the carrier from source 11, it being understood as above explained that the frequency succession of the waves from source 11 differs from instant to instant from the frequency succession of the waves from source 8. In each case the difference frequencies were selected. In column one, are several representative frequencies of the original speech. In column two, are the frequencies to which the original representative speech frequencies have been changed by the modulation by the 3500 cycle carrier and selection of the "difference" sidebands. In column three, are the corresponding frequencies after the second modulation by the carrier varying between 4500 and 6000 cycles. Three values are given for three representative instantaneous values of the output of the second stage varying carrier. In column 4, 5 and 6 are the frequencies of the original components after the third modulation 4, 5 and 6 each being a representative frequency of the third carrier.

In Fig. 2B is represented the transformation of these transmitted frequencies back to their original form at the receiver. Columns 1, 2 and 3 represent the various representative frequencies of the scrambled speech (the same as column 4, 5 and 6 of Fig. 3A), column four the frequencies after the first modulation, column five the frequencies after the second modulation and column six the frequencies back to their original form, after the third modulation. Of course, the corresponding carriers at the transmitter and receiver must be of the same frequency at all times. Using the three modulators in this case it is apparent that the speech is not only continuously varied in frequency but is also inverted. This inversion is not a necessary part of the system. In fact, if four modulators were used the speech would not be inverted. Secrecy is afforded because of the fact that each speech component is raised and lowered in frequency several times a second by the same amount, thus the harmonic relations are not at all maintained and the fast variations of the speech frequencies perfectly disguise all intelligence. It will be noted that no signal is emitted while there is no speech, and the signal being emitted while speech is being transmitted is of a frequency dependent on the frequency of the speech and of each of the three or more carriers. Thus to determine the speech frequencies from an analysis of the outgoing frequency it would be necessary to know the frequency of each of the carriers at all instants. To analyze the frequency of any one of the carriers it would be necessary to know the frequency of the speech and of each of the other carriers. Such a resolution of the signals is impossible when they are all multiplied together as is done in successive modulators.

In Fig. 3A is diagrammed a source of the carrier frequencies as used for both transmitter and receiver, it being understood that identical equipment is located at the transmitter and at the receiver. A method of and means for framing transmitter and receiver carriers are also explained. On the periphery of disc 21, driven by a synchronous motor 22, controlled by standard power source 23, is recorded a sound track 24 of haphazard varying frequencies between 4500 and 6000 cycles. These frequencies can be generated for recording on disc 21 in several ways. An audio oscillator can be used with its frequency changed manually, or a sine wave constant amplitude audio oscillator can be frequency modulated by a second low frequency oscillator over the desired range, with the frequency, wave form, amplitude and D. C. component of this second oscillator variable and controlled manually. Such manual controls afford an infinite number of combinations, because of the human element, and the recorded frequency variations are truly haphazard. No two similar recordings can ever be made unless one recording is used as a master for others. An infinite number of different recordings with the desired number of copies, can be quickly and simply made, so any secrecy installations can be quickly and continuously supplied with the new discs. These recordings can be effected either on an ordinary waxed record blank or by means of sound-on-film or any other known method of recording. The recording can be either a spiral long running track or a circular track forming an endless repeating record, the latter form being preferred. Scanning this sound track are two pickups 25 and 26 which serve as the sources of the carriers 8 and 11 for the modulators 7 and 10 in Fig. 1A or Fig. 1B. The positions of pickups 25 and 26 to each other are adjustable to a calibrated position, so that each pickup engages the sound track at a different position from the others.

For the purpose of framing the transmitter and receiving units, a second track 27 is recorded simultaneously with track 24 on disc 21, the recording of track 27 being a linear variation of frequency around the periphery of the disc. The frequency of track 27 may range between 400 and 4000 C. P. S., or any other frequency range suitable for transmission. The pickup 28 for this track 27 is connected to the fixed contacts 13*a* and 13*b* of a double pole double throw switch 13 so that the framing frequency may be transmitted at will to the receiver. Pickup 28 is made adjustable to a calibrated position in relation to pickups 25 and 26. Thus all three pickups are arranged so that they may be placed in any predetermined position around the periphery of the discs at both the transmitter and receiver. For framing, the signal from track 27 is sent over the wire or radio link to the receiving station and there the receiving operator by means of switch 13' and suitable comparing apparatus will mix this signal with that from his own framing track and will adjust the relative position of his disc until both framing signals are of the same frequency, thus making the position of his disc in relation to the three pickups correspond with that of the transmitting station. This transmitted signal has nothing to do with the secrecy so can be transmitted at will. Since the transmitting and receiving stations have set their pickup arms at a prearranged position, and since the transmitting and receiving discs are identical regarding both track 24 and track 27, the framing

of track 27 causes the carriers 8 and 11 (Figs. 1A, 1B) from pickups 25 and 26 (Fig. 3A) to be in frame and the transmitter and receiver at their respective correlated stages will have the same carriers at all instants. A receiver which is framed with a transmitting station is also in frame to act as a transmitter to all other receivers which are also in frame with the original transmitter and which are using the same scrambling-framing discs. Taking into account the changes of transit time of signals coming over the air and, furthermore, taking into account the error in cutting the disc driving gears, I have determined that these limits impose a disc speed of one revolution every eight seconds with the frequencies recorded thereon varying from one extreme of the range to the other no more than eight times a second. A disc of twelve to fourteen inches diameter will allow linear recording between 4500 and 6000 C. P. S. at this angular speed.

The relative positions of the three pickup arms permit upwards to 100,000 possible adjustments. Thus if the equipment should be captured by the enemy it would be necessary for them, in order to make use of it, to record the signal as received from the transmitting station upon material running at an absolutely constant synchronous speed, then playing back this recording at the same synchronous speed many times over, each time starting his recording at the same instant he starts his captured unscrambling disc, and each time readjusting the relative positions of the two pickups 25 and 26. Since 100,000 combinations are possible, the chances are remote that the message will be intercepted. This procedure must be repeated for each separate recording the enemy makes of an intercepted message. Furthermore, the combination of the relative position of the pickups can be changed any number of times during a transmission with only a slight delay for the adjustment, affording still more secrecy. These discs are very easily made and the disc itself can be changed at will, thus rendering the entire equipment captured by the enemy useless until he captures the disc being used and looks for his one chance out of the 100,000. The equipment can be made still more complicated by changing the speed slightly at which these discs are turning.

To allow for one disc drive motor drifting with respect to the other, any well-known arrangement can be employed to restore the proper phase and time synchronism so as to bring the two discs into "frame" with each other. Since such a drift will be very slow of course, it can be easily adjusted by suitable manual adjustments of the receiving motor 22 until a "fuzzy" voice signal becomes easily understandable again. It will be understood of course that the various pick-up devices are mounted on suitable arms or supports which may be provided with vernier adjustments so that the relative positions of the pickups with relation to their respective sound tracks can be accurately adjusted.

Instead of employing two pickups working on a single track as in Fig. 3A, each pickup may be provided with its individual sound track. Such an arrangement is schematically illustrated in Fig. 3B, wherein the phonogram 21 comprises four sound tracks 31, 32, 33, 34. Track 34 corresponds to track 27 of Fig. 3A, and with its pickup 37 it is used for generating the "framing" signal. Track 31 and its associated pickup 35 are used to generate the variable frequency carrier 8 (Fig. 1A); while track 32 with its associated pickup 36 is used to generate the variable frequency 11 (Fig. 1A). If desired, an additional track 33 can also be provided with an individual pickup (not shown), and by suitable switching means (not shown), the pickups can be connected in any selected pairs to the corresponding modulators of Figs. 1A and 1B. It will be understood of course that the receiver of Fig. 1B is equipped with mechanisms identical with those used at the transmitter, and by means of the "framing" signal the predetermined orientation of the pickups at the receiver with respect to the receiver phonogram can be accurately determined. It will also be understood that the phonogram records at the transmitter and at the receiver are identical and necessarily made from the same master record. Instead of using the third track 33 as a switch-over track as above described, it may be used to deliver variable frequency carrier to a third variable modulation stage similar to stages 7 and 10 (Fig. 1A), and stages 7' and 10' (Fig. 1B).

In the event that three varying frequency modulation stages are to be employed at the transmitter and receiver instead of two stages as above described, and instead of using three separate tracks and three separate pickups for generating the variable carrier frequencies for these three stages, the phonogram may be formed with a single continuous sound track 38 of continuously but irregularly successive frequencies, and a series of three pickups 39, 40, 41, are mounted in adjustable calibrated position with respect to the track 38 so that no two pickups generate the same frequencies at successive instants. A corresponding phonogram is used at the receiver and the respective three pickups are likewise framed and orientated with respect to the corresponding track on the receiver phonogram disc. The track 42 and its associated pickup 43 at the transmitter generate the "framing" signal, and the corresponding track and pickup at the receiver are used for comparison purposes as above described to determine the proper framing. In the case of three variable carrier modulation stages, the number of possible combinations of adjustment are increased to the order of thirty million. Such an arrangement of phonograms and pickups is schematically illustrated in Fig. 3C.

Instead of employing a disc-type phonogram, the various frequencies can be recorded on an endless sound film or the like. Such an arrangement is schematically illustrated in Figs. 3D and 3E wherein the film 44 is provided with two sound tracks 55, 56. The film may be an endless one adapted to be moved at the required speed by motor 22 and standard frequency power source 23 to generate the necessary variable carrier frequencies. Associated with the film are three pickups each comprising a light source 45 which illuminates three separate and suitably mounted optical systems 46, 47, 48, with their associated light-sensitive cells 49, 50, 51. Preferably, the film is sufficiently long so that it can be multiply looped and fed through adjustable storage tanks located between each pickup so as to adjust effectively the distance between the pickups. It will be understood of course that each of the pickup systems includes a "light-slit" plate 52, 53, 54 (Fig. 3E) so as to scan the respective sound tracks in elemental areas as is well-known in the sound recording and reproducing arts. In this embodiment the pickups 49 and 50 with their associated aperture plates 52, 54, and sound track 55, correspond to the carrier frequency pickups for supplying the variable frequencies 8, 11 (Fig.

1A), and 9', 11' (Fig. 1B), while the pickup 51 with its associated aperture plate 53 cooperate with sound track 56 to generate the framing signals at the transmitter and at the receiver. It will be understood of course that any other well-known form of record or phonogram such as a steel tape or the like may be used in place of the disc and belt phonograms above described.

While in the foregoing description, reference has been made to "sum" and "difference" frequencies of the modulated carriers, it will be understood that these are used in their broader sense to include the sideband components of multiplication products of the modulated carriers. Furthermore the expression "carrier" as employed herein is used in a generic sense to include any source of current having an alternating or corresponding fluctuating component which can be modulated to produce sidebands or "sum" and "difference" frequencies by modulation with signal frequencies.

Various changes and modifications may be made in the several disclosed embodiments without departing from the spirit and scope of the invention. Thus while the second variable carrier stage is described as employing the same band of frequencies, viz. 4500–6000 cycles as the first variable stage this is merely illustrative and any other band, e. g., 6500–8000 cycles may be employed for the second stage provided it has the same band width as the first stage.

What I claim is:

1. The method of secret signaling which includes the steps of converting a given signal into a wave having an A. C. component representing the signal, varying the frequency of said component at an irregular frequency succession which is independent of the frequency succession of the signal itself, and again changing the frequency of said converted component at another irregular frequency succession different from the first-mentioned succession.

2. The method of secret signaling which includes the steps of, generating carrier waves of irregular coded frequency succession, modulating said waves by a given signal whereby at successive instants said signal is represented by carrier waves of irregular coded frequency succession, generating other carrier waves of irregular coded frequency succession which is different from the first-mentioned succession, selecting predetermined frequency components of the first-mentioned modulated carrier waves, modulating said other carrier waves by said components, and selecting predetermined frequency components of said other modulated waves.

3. The method according to claim 2 in which the "difference" frequency components of the first and second-mentioned carrier waves are selected.

4. The method according to claim 2 in which the "sum" frequency components of the first and second-mentioned carrier waves are selected.

5. The method according to claim 2 in which said signal is a voice-frequency signal and it is passed through a distorter prior to modulating the first-mentioned carrier whereby the normal relation between the fundamental and harmonics of the original voice frequency wave is arbitrarily changed.

6. The method according to claim 2 in which the signal is a voice frequency signal which has been limited so that its uppermost frequency is less than the lowermost frequency of either of said carriers.

7. The method according to claim 2 in which the frequency band of the first-mentioned carrier is the same as the frequency band of the second-mentioned carrier.

8. The method of secret signaling which includes the steps of converting a given voice frequency signal into a plurality of modulation products having arbitrary frequency variations of irregular frequency succession, selecting a component of said products, converting the selected component into other modulation products also of arbitrary frequency variation of irregular frequency succession different from the frequency succession of the first-mentioned modulation products, and selecting a component of said second modulation products for transmission to a distant station.

9. The method of secret signaling which includes the steps of converting a voice frequency signal in successive modulation stages to produce successive modulation products with the frequency band in each stage substantially the same but with the frequency distribution in each band different and having irregular frequency succession which is independent of the frequency succession of the signal itself, selecting for transmission predetermined components of the output of the final stage, receiving said components, subjecting the received components to successive modulation stages to produce successive modulation products with the frequency succession in each stage substantially the same as the frequency succession of corresponding modulation stages at the transmitter but with the frequency succession in each stage at the receiver different from the preceding stage thereof.

10. The method of secret signaling which includes the steps of generating a first band of carrier waves of irregular coded frequency succession, modulating said waves by a given signal whereby at successive instants said signal is represented by carrier waves of different irregular frequency succession generating a second band of carrier waves having substantially the same limits as the first band and also of irregular coded frequency succession which is different from the succession of the first band, selecting predetermined frequency components of the first-mentioned modulated carrier waves, modulating said second-mentioned carrier waves by said selected components, selecting predetermined frequency components of the last-mentioned modulated waves, transmitting the last-mentioned selected components over a communication link, generating at the receiving end of said link a first band of carrier waves having the same frequency succession as that of said second band of carrier waves at the transmitter, generating at the receiving end another band of carrier waves having the same frequency succession as that of said first band of waves at the transmitter, modulating the second band of carrier waves at the receiver by selected components from the first band of carrier waves at the receiver, selecting predetermined components of the second band of modulated carrier waves at the receiver, and controlling a signal reproducer by the last-mentioned selected components.

11. The method of secret signaling which includes the steps of modulating a carrier source of fixed frequency by signals to produce a fixed series of modulation products representing said signal, selecting a component of said products, generating a first set of varying frequency carrier waves of irregular coded frequency succession, modulating said varying frequency carrier by said selected component, generating a second set of

varying frequency carrier waves of irregular coded frequency succession different from the first-mentioned succession, selecting a predetermined component from the modulated first set of carrier waves to modulate the second set of carrier waves, and selecting a predetermined frequency component of the modulated second set of carrier waves.

12. The method according to claim 10 in which said given signal is in the form of a modulated carrier of unvarying frequency, and the selected component of the said second set of modulated carrier waves at the receiver is applied to modulate a fixed carrier of the same frequency as the carrier frequency of the said given signal, and a selected component of the modulated fixed carrier at the receiver is used to control said signal reproducer.

13. The method according to claim 11 in which prior to modulating said fixed frequency carrier at the transmitter by the signals the signals are first passed through a signal distorter to change the normal relation of the fundamental and harmonics of the signal.

14. A secret signaling system according to claim 2 in which is generated a carrier of fixed frequency, and said fixed frequency carrier is modulated by the original signals prior to modulating the first-mentioned band of carrier waves.

15. In a secret signaling system, a transmitter comprising signal input terminals and signal output terminals, a plurality of modulation stages between said input and output terminals, each stage being supplied with carrier frequencies within the same band but such that at successive instants the frequencies applied to the two stages are different, means to modulate the first stage carriers under control of an input signal, means to select modulation products of the first stage, means to modulate the second stage by said selected modulation products, and means to select certain modulation products from the second stage to represent said signal.

16. A secret signaling system according to claim 15 in which a preliminary modulation stage is provided between the first of said plurality of stages, said preliminary stage comprising a source of fixed frequency carrier, means to modulate said fixed frequency carrier by the signal, and means to select certain modulation products from said preliminary modulation stage for application to the first of said plurality of stages.

17. A secret signaling system according to claim 15 in which each of said plurality of modulation stages comprises a double balanced modulator, and the said selected modulation products of the stages are "difference" frequencies.

18. A secret signaling system according to claim 15 in which each of said plurality of modulation stages comprises a double balanced modulator, and the said selected modulation products of the stages are "sum" frequencies.

19. A secret signaling system according to claim 15 in which a distorting network is provided before the first modulation stage and upon which network the signals are impressed to change arbitrarily the normal relation between the fundamental and harmonic components of the original signal.

20. A modulation arrangement for secret signaling systems comprising a plurality of modulator stages each of a type which produces in its output substantially only sum and difference components, and means to supply each stage with a band of carriers of continuously varying frequencies which are independent of the frequency successions of the signal to be transmitted but with the frequency succession in succeeding stages different.

21. A secret signaling system comprising a transmitter and a receiver each having a modulation arrangement comprising a plurality of double balanced modulators and means to supply each modulator with a similar band of carriers, the carriers applied to the stages at the transmitter looking in a direction from the input to the output of the transmitter being synchronized with the carriers applied to the stages at the receiver looking in a direction from the output to the input of the receiver, the frequency succession of the several carrier bands at the transmitter being different from each other.

22. A system according to claim 21 in which test means are provided to determine when the corresponding stages at the transmitter and receiver are properly synchronized.

23. A scrambler for secret signaling systems comprising in succession a signal distorter for changing arbitrarily the normal relation between the fundamental and harmonics of a voice input signal, a first balanced modulator supplied with a carrier of frequency F, a filter for suppressing all except one side band from said first modulator; a second balanced modulator supplied with continuously varying carriers of frequencies F_a—F_b; a filter for suppressing all except one side band from said second modulator; a third balanced modulator supplied with continuously varying carriers of frequencies F_a—F_b but with a different frequency succession from the carriers supplied to the second modulator; and a filter for suppressing all except one side band from said third modulator.

24. An unscrambler for secret signaling systems comprising in succession a first balanced modulator supplied with continuously varying carriers of frequencies F_a—F_b; a filter for suppressing all except one side band from said first modulator; a second balanced modulator supplied with continuously varying carriers of frequencies F_a—F_b but with a different frequency succession from the carriers supplied to the first modulator; a filter for suppressing all except one side band from said second modulator; a third balanced modulator supplied with a single carrier of frequency F; a filter for suppressing all except one side band from said third modulator; a signal "restorer" network for restoring the proper relation between the fundamental and harmonics of an original voice signal to be reproduced; and a signal reproducer controlled by said restorer.

25. A secret signaling system having a scrambler according to claim 23 and having an unscrambler, said unscrambler comprising in succession a first balanced modulator supplied with continuously varying carriers of frequencies F_a—F_b; a filter for suppressing all except one side band from said first modulator; a second balanced modulator supplied with continuously varying carriers of frequencies F_a—F_b but with a different frequency succession from the carriers supplied to the first modulator; a filter for suppressing all except one side band from said second modulator; a third balanced modulator supplied with a single carrier of frequency F; a filter for suppressing all except one side band from said third modulator; a signal "restorer" network for restoring the proper relation between the fundamental and harmonics of an original voice signal to be re-

produced; and a signal reproducer controlled by said restorer.

26. A secret signaling system according to claim 15 in which the carrier supply for each of said stages comprises a member having a record of the sound track type of continuously but irregularly varying frequency, and a pair of pickups in cooperation with said record but spaced apart so as to generate at any given instant different carrier frequencies.

27. In a secret signaling system, a transmitter and a receiver, each having a plurality of modulator stages, each stage having means to supply it with carrier frequencies continuously and irregularly varying over a predetermined band, the last-mentioned means including a phonogram record at the transmitter and a plurality of pickup devices associated therewith so that each pickup generates a different frequency succession from the other, and another phonogram record at the receiver having a corresponding plurality of pickups associated therewith, and means to control both the phonograms so that the carrier frequencies supplied to correlated stages at the transmitter and receiver are in synchronism while the carrier frequencies supplied to successive stages at the transmitter are different at any given instant.

28. A secret signaling system according to claim 27 in which the phonogram record at each station is in the form of a member having a "sound" track record of a continuously varying haphazard succession of frequencies within said predetermined band.

29. A secret signaling system according to claim 27 in which the phonogram record at each station is of the endless band type.

30. In a secret signaling system of the type wherein original voice-frequency signals are converted into scrambled frequencies at a transmitter and are unscrambled at a receiver by variable frequency carriers, means to generate a plurality of sets of carriers at the transmitter and similar means to generate a plurality of sets of carriers at the receiver, each of said means comprising a record having a plurality of sound tracks, each track being a record of a continuously varying frequency having irregular frequency succession, a pair of pickups for simultaneous cooperation with the record to generate said variable carriers for scrambling and unscrambling, and a third pickup cooperating with the record to generate "framing" impulses to compare the position of the said pair of pickups with respect to the record.

31. A system according to claim 30 in which said three pickups are mounted in predetermined relationship to each other at the transmitter and at the receiver, and means are provided for comparing the "framing" impulses of the transmitter and the receiver to control the relative positions of said pair of pickups with respect to the record.

32. A system according to claim 30 in which the record comprises two sound tracks, one for simultaneous cooperation with said pair of pickups and the other for cooperation with the third pickup.

33. A system according to claim 30 in which said record comprises at least three separate sound tracks each cooperating with one of said pickups.

34. A system according to claim 30 in which said record comprises at least four sound tracks, three of which are selectively cooperable with said pair of pickups, and the fourth is cooperable with the third pickup.

35. The method of secret signaling which comprises generating voice-frequency signals limited to a band F_1—F_2, converting said signals into a modulated carrier of frequency F_3 above the band F_1—F_2, converting said modulated carrier into an irregular frequency succession of other modulated carriers within the band F_4—F_5 above the band F_1—F_3, converting said other modulated carriers into a further irregular frequency succession of modulated carriers of the band F_4—F_5, and transmitting selected components of the last-mentioned modulated carriers to a receiving station.

36. The method of secret signaling employing a series of plural modulation stages with variable carriers at the transmitter and at the receiver, which includes the steps of, recording on a phonogram an irregular succession of frequencies for controlling the generation of said carriers, and simultaneously recording on said phonogram another series of frequencies for controlling the generation of a framing signal to control the synchronization of correlated carriers at the transmitter and at the receiver.

37. The method according to claim 36 in which the frequency succession of the framing signal varies in a regular time relation.

38. The method according to claim 36 in which the recording of said variable carrier frequencies is varied manually during recording in a haphazard manner.

39. The method according to claim 36 in which said succession of said irregular frequencies is varied during recording by manually varying a recording oscillator in an irregular manner.

40. The method according to claim 36 in which a pair of said phonograms are employed at the transmitter and receiver to generate the said variable carriers, and said phonograms are framed by comparing the frequency of the framing signal from the transmitter with the frequency of the framing signal at the receiver.

41. The method secret signaling according to claim 36 in which an identical pair of said phonograms are used at the transmitter and receiver, and three pickups are employed at the transmitter and three pickups are employed at the receiver, two pickups at the transmitter cooperating with the variable frequency carrier part of the phonogram and two pickups at the receiver cooperating with the variable frequency carrier part of the phonogram at the receiver, the third pickup at each station cooperating with the framing part of the phonogram thereat, and means to transmit to the receiver a framing signal under control of the third pickup at the transmitter for comparison with the framing signal at the receiver.

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