Aug. 4, 1931. R. BOWN 1,816,953

PRIVACY SIGNALING SYSTEM

Filed Sept. 24, 1929

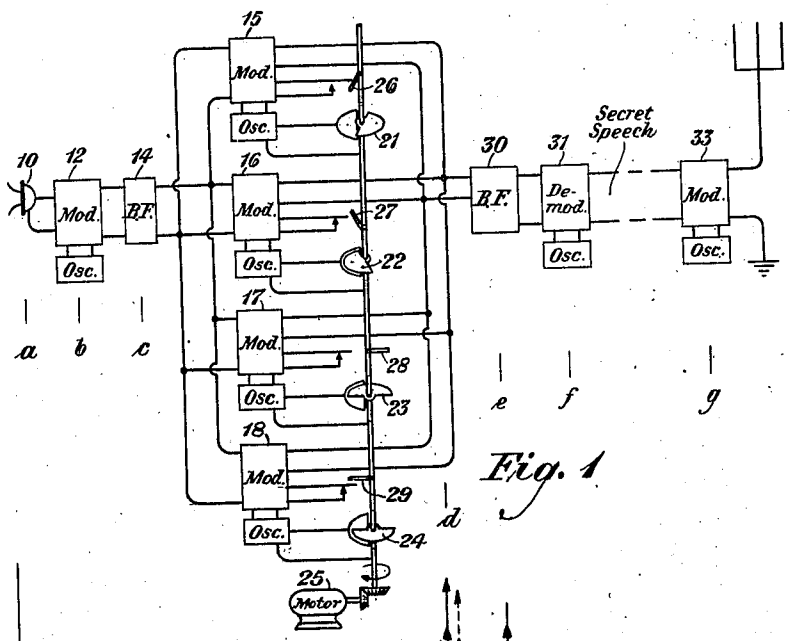


Fig. 1

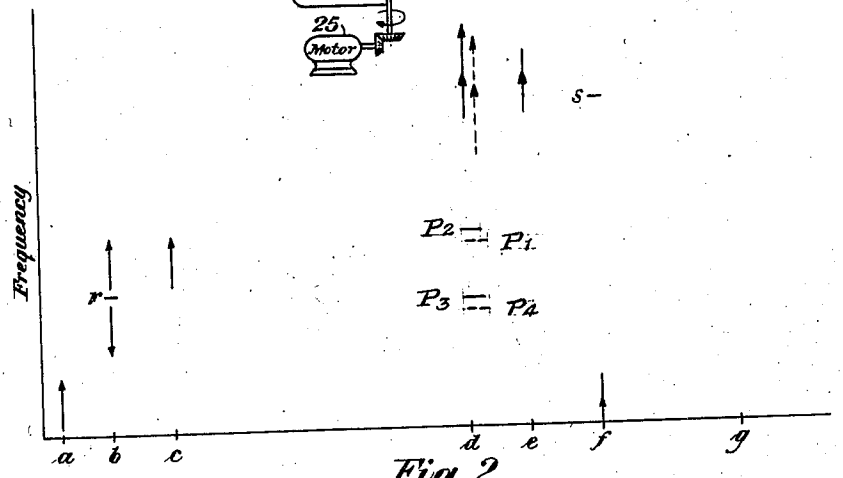


Fig. 2

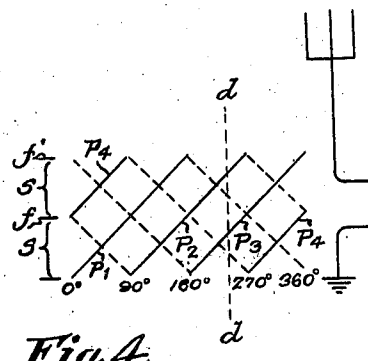


Fig. 4.

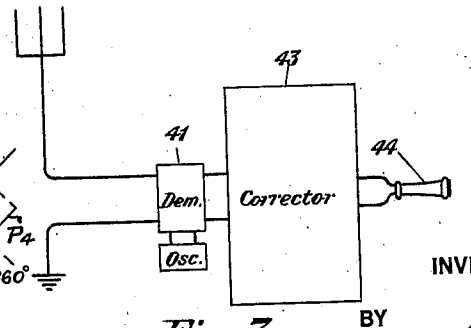


Fig. 3

INVENTOR
R. Bown
BY
ATTORNEY

Patented Aug. 4, 1931

1,816,953

UNITED STATES PATENT OFFICE

RALPH BOWN, OF MAPLEWOOD, NEW JERSEY, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK

PRIVACY SIGNALING SYSTEM

Application filed September 24, 1929. Serial No. 394,898.

This invention relates to privacy systems for radio circuits and its purpose is to render more complete than heretofore the secrecy which may be attached to radio communication.

Heretofore it has been proposed in the case of speech to obtain secrecy by splitting the voice frequency band into a number of sub-bands which are then rearranged with respect to each other and in this new unintelligible form are transmitted to a remote station. It has further been proposed to change this arrangement from time to time to defeat the efforts of those who may attempt surreptitiously to decode the message. Certain disadvantages are inherent to such an arrangement, among others being the effects arising from the sudden changing from one arrangement to another.

In my invention I rearrange the voice frequency band and change the configuration of the arrangement smoothly and continuously. I cause the speech band to move upward (or downward) in the frequency range and as the band passes from its normal position, that portion of it which goes outside the normal band limits is transferred to the position left vacant at the other edge of the band, thus yielding a continuous but cyclically changing arrangement of the portions of the original speech signal.

The invention will be better understood from the following specification taken in connection with the accompanying drawings in which Figure 1 shows a radio transmitting station in which the purposeful mutilation of the speech signal to be transmitted is accomplished, after which it is impressed on a radio carrier frequency; Fig. 2 is a diagram illustrating the shiftings of the speech signal band as it passes through the apparatus of Fig. 1; Fig. 3 shows schematically the circuit at the receiving station; and Fig. 4 is a diagram illustrating the shifting of the carrier frequencies.

Referring more particularly to Fig. 1, there is shown a microphone or other source of speech signal at 10. This speech signal is modulated against a comparatively low carrier frequency r in a modulator 12. The input of this modulator is then impressed on a band filter 14 which is arranged to transmit one side band only. Either side band is suitable but in this specification I am describing the invention in terms of the upper side band. The output from this band filter is now impressed in parallel on four modulating devices 15, 16, 17 and 18, supplied with different carrier frequencies. The oscillators supplying these respective carrier frequencies are arranged to have their frequency varied cyclically by any suitable means, such, for example, as the variable condensers 21, 22, 23 and 24, the adjustable portion of which is driven continuously by a constant speed motor 25, the variable elements of the condensers all being mounted on a shaft rotated by this motor.

The frequency of each of these oscillators moves over the same range, the range in this description being twice that of the width of the speech band. Any one of them which starts at a certain moment with its minimum frequency, proceeds continuously in half a revolution of a condenser to its maximum value and then falls continuously to its minimum value, repeating this process indefinitely. The other oscillators follow the same course, being displaced 90 degrees one behind the other. Thus there appears, among other things, in the output of the four modulators, taken together, four upper side bands, of which two at least are adjacent to each other, moving smoothly upwards in their frequency location and each corresponding to the original speech signal.

This will be clear from Fig. 4, in which four carrier waves p_1, p_2, p_3, and p_4 vary in frequency over a range $2s$ equal in width to two side-bands of width s. Each frequency completes a cycle of frequency variation in a time interval which is represented in the diagram by 360 degrees. The rising part of each curve showing frequency variation is in full lines and the falling part in dotted lines. The four curves representing the frequency variation of the four carrier waves are 90 degrees out of phase with respect to each other. The side bands associated with any two carriers which are both rising at the same

time will lie adjacent and one above the other.

The invention as thus far described will be better understood by reference to Fig. 2 in which abscissæ represent various points along the circuit and the ordinates represent the frequency or frequency bands appearing at a given portion of the circuit. Thus in Fig. 1 various portions of the circuit have been represented by the letters *a*, *b*, *c*, etc., and the corresponding points are indicated on Fig. 2. At the microphone there is generated a speech signal of a certain width which might, for example, be taken as extending from substantially zero to about 3,000. This band of frequencies has been indicated at *a* in Fig. 2. After modulation against the carrier frequency *r* there appears in the modulator at *b* the carrier frequency and the upper and lower side bands but at *c* the carrier frequency and the lower side band have been suppressed, leaving only the upper side band. This is shown in Fig. 2 and correctly indicates that the effect of the elements 12 and 14 has been solely that of shifting the speech frequency as found at *a* to a higher level by the amount *r*. In the output of the modulators 15 to 18 there will appear, as shown at *d* in Fig. 2, the four carrier frequencies p_1, p_2, p_3 and p_4 along with the side bands which generally are adjacent to each other and each of which corresponds to the original speech band lifted to a higher frequency level. As the carrier frequencies go through their cyclical changes, these side bands will move up or down in the frequency level in precisely the same manner.

The condition represented in Fig. 2 at *d* is that corresponding to the instant *d*—*d* in Fig. 4. The side bands corresponding to carrier waves p_3 and p_2 are both moving upwards adjacent each other and the side bands corresponding to waves p_1 and p_4 are falling, the carriers p_1 and p_4 having fallen to values slightly below p_2 and p_3, respectively. The arrows representing the falling side bands are shown in dotted lines, and for reasons which will appear later the side bands while falling are suppressed.

By means now of a band filter 30 a section of the side band group is transmitted, the width of the selected section being equal to the width of the original speech band. As shown in Fig. 4, the cut-off points *f* and *f'* of the filter may correspond to the midpoint and maximum values of the range 2*s* through which the carrier waves vary in frequency. As shown at *e* in Fig. 2 and at the particular instant illustrated in the figure, there is transmitted an upper portion of the side band corresponding to the carrier p_3 and a lower portion of the side band corresponding to the carrier p_2, these two portions together giving a full representation to the original message but being rearranged in such a way as to yield unintelligible speech in that form. Furthermore, as the carrier frequencies shift, a different portion of each of these two side bands or of a third side band will be transmitted so that there is a continual change in the distortion or mutilation which has been applied to the original speech band. As seen from Fig. 4 the range of frequencies in the selected band will pass through one cycle of rearrangement during one-fourth of a cycle of frequency variation of the carrier waves.

In Fig. 1 the output of this band filter 30 is impressed on a demodulator 31 supplied with a carrier frequency *s* of such a value as to shift the band from the filter 30 to the zero frequency level, that is, the level corresponding to the original speech band at the microphone 10. This shift is indicated in Fig. 2 at *f* and it will be observed that the mutilation at the point *e* in the circuit is maintained, and from the output of the demodulator 31 there issues what may be called "secret speech".

For the purposes of my invention this secret speech may now be used for modulating a radio frequency wave and thus transmitted to a remote station. This is indicated in Fig. 1 by the modulator 33.

It is evident that by the reverse process the secret speech could be restored to normal intelligible speech. Fig. 3 shows a radio receiving station having a demodulator 41 the output of which goes to a correcting circuit 43 containing appropriate band filters and modulators to perform precisely the reverse operation of that which has been described in connection with Fig. 1 and thus applying finally to the receiver 44 a reproduction of the original speech message.

Referring again to Figs. 1 and 2, it is seen that there might be confusion between one of the side bands which is rising as its carrier frequency rises and one of the other side bands which is falling in frequency level at the same time, and in such manner that their carrier frequencies might be at or near the same value. This would lead to undesirable effects and I therefore make provision to remove from operation any modulator circuit while its carrier frequency is falling in value. This may be accomplished in a number of ways and a convenient method which is shown in Fig. 1 is to have contact elements 26, 27, 28 and 29 on the rotating shaft of the condenser plates which open the modulator circuits for half of the time, namely, that portion of the time while the oscillator frequency is being restored to its lower value and leaving the circuit closed during the time that the oscillator and therefore its corresponding side band is moving upwards in the frequency. It is to be understood that this method of upward movement is used for illustration only and that it would be equally effective to use

the side bands while they are moving downwards in the frequency range.

It is evident that the rotating condensers at the receiving station must move in synchronism with the rotating condensers of Fig. 1. For this reason I find it preferable to have these motors run at constant speed such, for example, as may be obtained from tuning fork driven motors which are extremely constant. However, it is to be understood that a variable speed in these motors may be used, the only requirement being that the two motors shall remain strictly in synchronism.

While the invention has been described in a specific form, it is to be understood that numerous variations may be made without departing from the spirit of this invention. For example, it is to be recognized that modulation with elimination of the carrier and one side band is equivalent to merely shifting the signal from one frequency level to another. Consequently in Fig. 1 it would have been possible to omit the modulator 12 and impress the speech signal directly on the plurality of parallel modulator circuits. The main purpose of this modulator 12 is to lift the signal band to such a frequency level that when it is modulated against the four carrier frequencies p_1, p_2, p_3 and p_4, the upper and lower side bands for any one carrier shall be sufficiently removed from each other and from the carrier so that there will be no difficulty in separation of the desired set of side bands from the total output of the modulators. Also, the function of the demodulator 31 is solely to lower the band which has been transmitted by filter 30 to original speech frequency level whereupon it is used for modulating a radio frequency oscillator. It would, however, be possible to omit the demodulator 31 and allow the output of filter 30 to be impressed directly on the modulator 33, the result being that the side bands associated with the radio signal would be further removed from the carrier radio frequency. This of course would result in the radio signal occupying a wider frequency band unless the method of signaling were used in which the carrier and one side band is suppressed.

It should be pointed out that this invention is not limited to four of the parallel modulators, and the group of four in Fig. 4 have been shown for illustrative purposes only. In general it would be desirable to reduce the amount of apparatus by reducing the number of such modulators and transmitting the desired portion of the output of these modulators through the band filter. Such decrease in number of modulators could be obtained by decreasing the time required for an oscillator to fall from its maximum to its minimum frequency value. This shortening of time might be obtained in any of a number of suitable ways, as by a cam motion, or by some spring action which would return a condenser plate to its initial position in a much shortened time, whereupon it would in due course be picked up to go through the useful portion of its cycle or, again, the same result might be obtained by having the stationary and movable plates or sets of plates non-parallel with respect to each other so that even with complete meshing of the two sets of plates the capacity will change continuously through a large portion of a complete cycle and a relatively small additional motion will then bring the condenser back to its starting position.

Also, it is not necessary that the carrier frequencies for these modulators shall be spaced as indicated earlier in the specification. They should be spaced sufficiently so that there will be no overlapping of the side bands, but they might be spaced further apart than this, and either uniformly or otherwise, the requirement being that the portion of the resultant side bands transmitted by the band filter 30 shall give representation to the whole of the original signal band. Also, while for simplicity the invention has been described in terms of the preservation of the upper side bands, it would have been equally feasible at any stage to have used the lower side bands, in which case the output at 31 would have corresponded to "inverted speech". This latter would have the advantage of contributing a further element of secrecy to this system of communication.

What is claimed is:

1. In a secrecy communication system, the method of obtaining secrecy, which consists in modulating the signal band against a plurality of carrier frequencies, causing the carrier frequencies to change continuously and cyclically, suppressing all but a band of width equal to the original signal band.

2. In a secrecy communication system, the method of obtaining secrecy, which consists in modulating the signal band against a plurality of cyclically varying carrier frequencies uniformly spaced and transmitting a portion of these only.

3. In a secrecy communication system, the method of obtaining secrecy, which consists in modulating the signal band against a plurality of cyclically varying carrier frequencies uniformly spaced and transmitting portions of these only which together will represent the whole of the original signal band.

4. In a secrecy communication system, the method of obtaining secrecy, which consists in modulating the signal band against a plurality of uniformly spaced carrier frequencies, selecting the side bands from these carrier frequencies, moving these continuously in one direction, and selecting from these a portion representing the whole of the original signal band.

5. In a secrecy communication system, the method of obtaining secrecy, which consists in raising the original signal band to a higher frequency level, modulating the resultant signal against a plurality of continuously varying carrier frequencies, spacing the carrier frequencies by an amount equal to the width of the original signal band, selecting from the resultant side bands a portion having the same width as the original signal band and modulating a radio frequency carrier with this last named portion.

6. In a secrecy communication system, the method of obtaining secrecy, which consists in raising the original signal band to a higher frequency level, modulating the resultant signal against a plurality of continuously varying carrier frequencies, spacing the carrier frequencies by an amount equal to the width of the original signal band, selecting from the resultant side bands a portion having the same width as the original signal band, modulating a radio frequency carrier with this last named portion, receiving the radio frequency signal at a remote station and performing the reverse operation to restore the original signal.

7. In a secrecy communication system, a plurality of carrier frequency sources, means for modulating each of these with a speech signal, means for changing the carrier frequencies cyclically over a definite range and a band filter for transmitting a band of the same width as the original signal band.

8. In a secrecy communication system, a plurality of equally spaced carrier frequency sources, means for modulating each of these with a speech signal, means for changing the carrier frequencies cyclically over a definite range in the same order, and a band filter for transmitting a band of the same width as the original signal band.

9. In a secrecy communication system, a plurality of equally spaced carrier frequency sources, means for modulating each of these with a signal band, the spacing between the carrier frequencies being such that the modulated side bands adjoin each other, means for changing the carrier frequencies cyclically over a definite range in the same order, a band filter for transmitting a band of the same width as the original signal band and so arranged that portions from more than one side band are transmitted but in a rearranged order.

10. In a secrecy communication system a plurality of equally spaced carrier frequency sources, means for modulating each of these with a signal band, the spacing between the carrier frequencies being such that the modulated side bands adjoin each other, means for changing the carrier frequencies cyclically over a definite range in the same order, a band filter for transmitting a band of the same width as the original signal band and so arranged that portions from more than one side band are transmitted but in a rearranged order, and means for demodulating to the original signal frequency band but in secret form.

11. In a secrecy communication system, a plurality of equally spaced carrier frequency sources, means for modulating each of these with a signal band, the spacing between the carrier frequencies being such that the modulated side bands adjoin each other, means for changing the carrier frequencies cyclically over a definite range in the same order, a band filter for transmitting a band of the same width as the original signal band and so arranged that portions from more than one side band are transmitted but in a rearranged order, and means for modulating a radio carrier frequency with the secret message.

12. In a secrecy communication system, a plurality of equally spaced carrier frequency sources, means for modulating each of these with a signal band, the spacing between the carrier frequencies being such that the modulated side bands adjoin each other, means for changing the carrier frequencies cyclically over a definite range in the same order, a band filter for transmitting a band of the same width as the original signal band and so arranged that portions from more than one side band are transmitted but in a rearranged order, and means at a remote station for performing the reverse operation to restore the original message.

13. In a secrecy communication system, the method of rendering speech signals secret which consists in causing a frequency signal band to move continuously across a band of definite width, said movement continuing at all times in the same direction, the portion disappearing beyond the limit at one edge reappearing at the other edge.

14. In a secrecy communication system, the method of rendering speech signals secret which consists in causing a frequency signal band to move continuously across a band of definite width, said movement continuing at all times in the same direction, the portion disappearing at the high frequency edge reappearing at the low frequency edge.

15. In a secrecy communication system, the method of rendering speech signals secret which consists in causing a frequency signal band to move continuously across a band of definite width, said movement continuing at all times in the same direction, the portion disappearing beyond the limit at one edge reappearing at the other edge, and selecting for transmission a band of the normal frequency band width but with portions transposed.

In testimony whereof, I have signed my name to this specification September, 1929.

RALPH BOWN.