July 10, 1928. A. CARPE 1,676,321

SECRECY SIGNALING SYSTEM

Filed Aug. 12, 1926

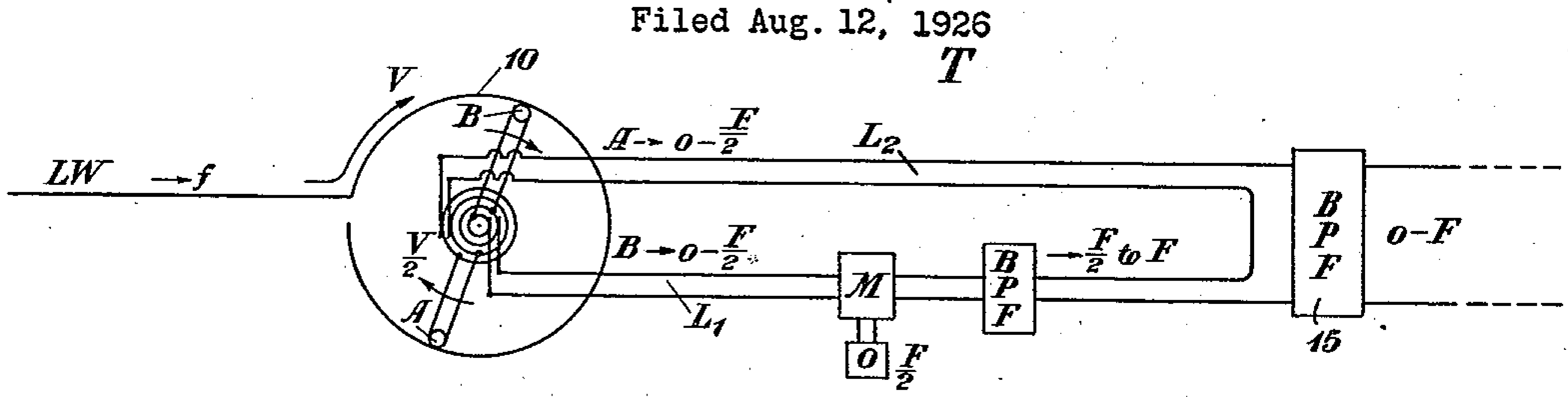

Fig. 1

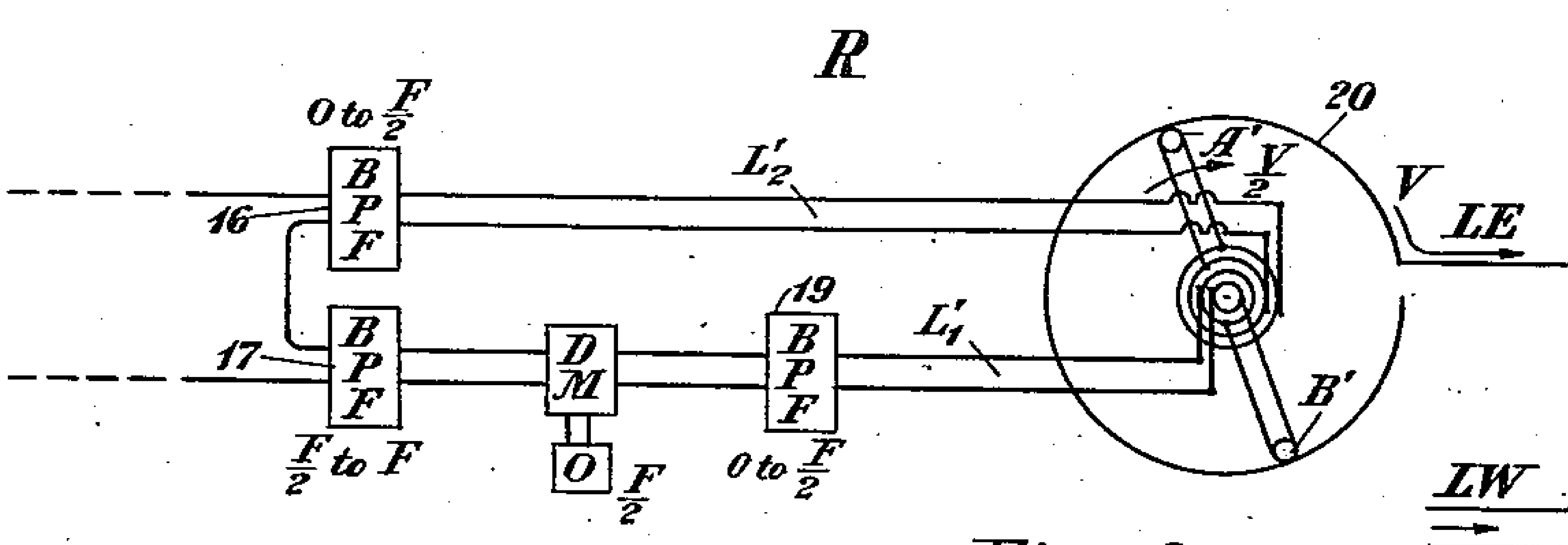

Fig. 2

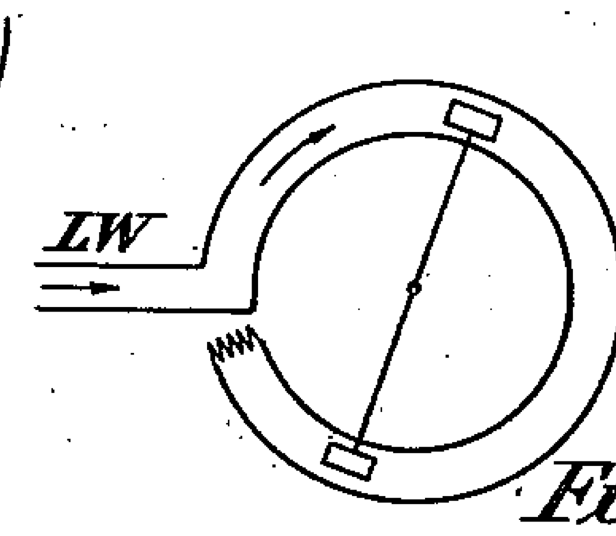

Fig. 5

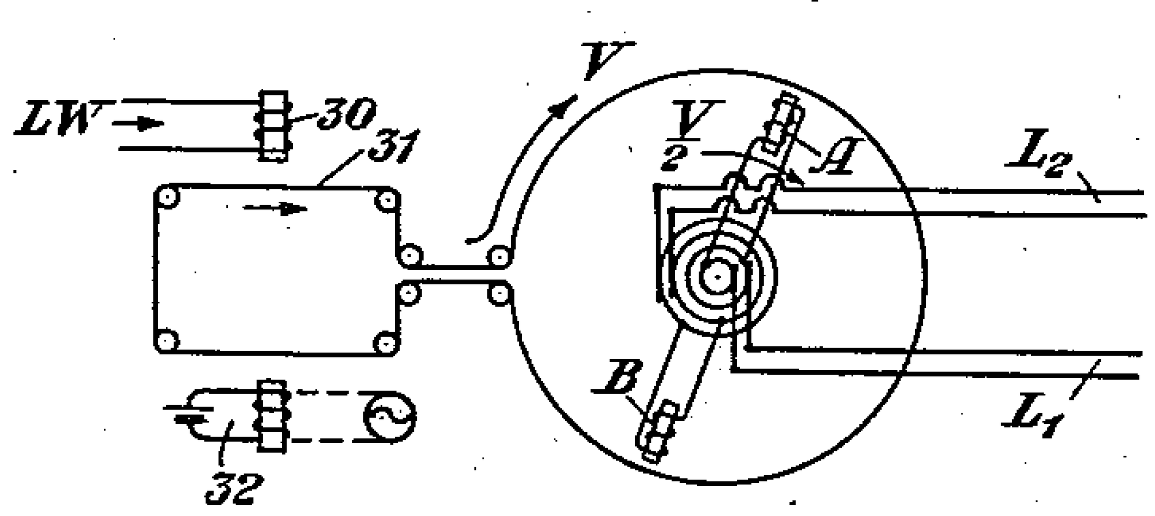

Fig. 3

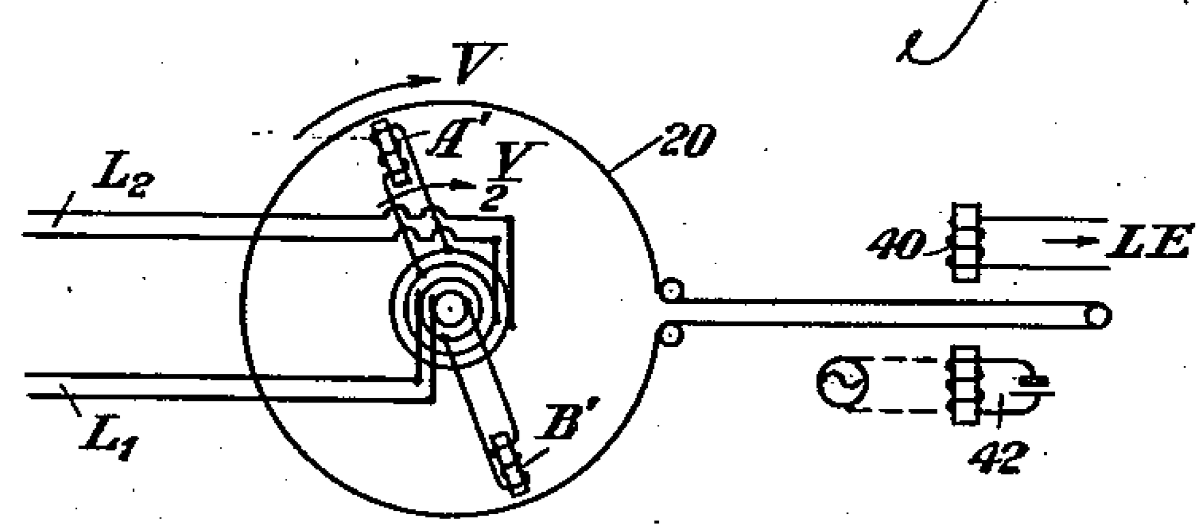

Fig. 4

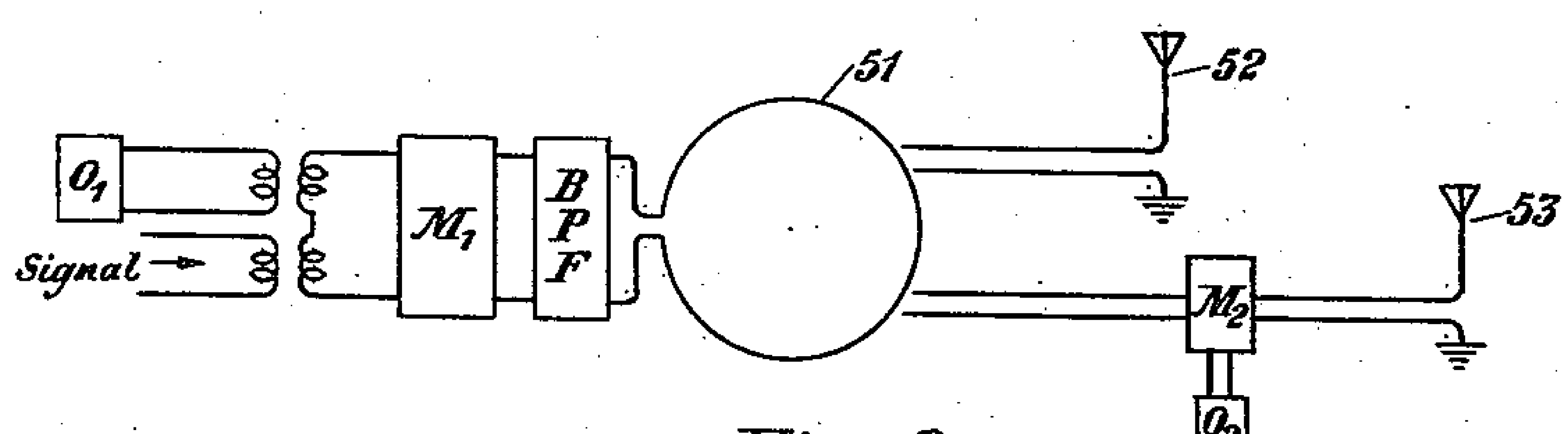

Fig. 6

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UNITED STATES PATENT OFFICE.

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SECRECY SIGNALING SYSTEM.

Application filed August 12, 1926. Serial No. 128,790.

This invention relates to a method of and means for secrecy signaling in which secrecy is obtained by having the signal so distorted during transmission that it will not be recognizable unless received by a station with the proper conversion means to correct the distortion. The invention is related to an application of French and Zinn, Serial No. 755,075, filed December 10, 1924, and to my application, Serial No. 128,789, filed Aug. 12, 1926.

In this invention I take a signal such as a speech signal, in which the frequency range is from about 100 to 5,000 cycles, and break it into segments or elements (preferably of equal length). Alternate elements which may be taken as a group are then applied to a device which lengthens the duration of each element and decreases each frequency and the frequency band occupied correspondingly. The other alternate elements making a group are also modified so as to occupy a narrower frequency band, preferably adjacent to but not overlapping the band of the first group of elements. In particular, in the case of normal speech messages, I find it advantageous to reduce all frequencies of the first group by the factor 2 so that this group may then occupy a frequency band corresponding substantially to the lower half of the original frequency band, while the second group has its frequency band width also reduced by the factor 2, but this band is so shifted by modulation as to occupy the upper half of the original frequency band. The two resulting bands are now superposed and transmitted to a receiving station at which the reverse process takes place. The complex wave is separated by filters into its components in separate paths. The component which was shifted by modulation is shifted back and the elements of the two portions are expanded to normal frequencies and frequency band width, and the elements are brought together in proper time relation to yield the original signal wave.

In the description which follows there will be occasion to make frequent references to the change of a frequency band width and also to a shifting of a frequency band. These two operations are distinctly different in character. As explained, for example, in the applications referred to above, a normal speech or music signal is a complex wave made up of numerous frequencies extending from about 100 to 5,000 cycles. Such a signal therefore is said to occupy a frequency band from 100 to 5,000. By means of the Doppler principle it is possible to change each and all of the frequencies in such a band by any desired factor, such as the factor ½, in which case the resulting signal would occupy a band from 50 to 2,500 cycles, and it will be apparent that while there has been a slight change in position of the frequency band, the important change has been in the width of the frequency band which has been altered by the factor ½. It is such a change as this which is referred to as reducing the frequency band width. On the other hand, if a normal speech signal is combined by modulation with a carrier frequency, there will then result modulation frequency bands which will be shifted with respect to the original band by an amount equal to the frequency of the carrier, but the width of one of these modulation bands will be unaltered; and it is such a change as this which will be in mind when reference is made to the shifting of a frequency band.

The invention will be better understood by reference to the following description and the accompanying drawing, in which Figure 1 illustrates a circuit arrangement for a transmitting station which is to carry out the distortion mentioned above; Fig. 2 illustrates the circuit elements and connections for a receiving station to co-operate with the transmitting station of Fig. 1; Figs. 3 and 4 show particular forms which the transmitting and receiving conversion devices may take on; Fig. 5 shows another form of such device; and Fig. 6 shows how the invention may be applied to radio signaling.

Referring more particularly to Fig. 1, LW may be taken to represent a path over which a normal speech signal may travel, the speech signal being made up of all frequencies from about 100 to 5,000 cycles, and it will be convenient to represent any of these frequencies by f and understand that they start from about zero. The incoming wave is allowed to pass over some form of path such as the circular path 10. Adjacent to said path 10 is a pick-up device A, adapted to reproduce the signal wave as it travels along the element 10, and to transmit this signal through brush contacts to the line L_1. If this pick-up device A is stationary, it is apparent that the whole signal wave entering upon 10 will be relayed to the line L_1 with no changes in form. On the other hand, if this device A is mounted to rotate about the center of the circuit 10, this will no longer be true. Let us suppose, for example, that the velocity of transmission of the wave along the element 10 is V and that the velocity of the pick-up device A is in the same direction and is equal to V/2. Consideration of the figure will then show that in one complete revolution of the element A there will be transmitted to the line L_1 an element of the message wave which would occupy half the circumference of the path 10, and that this segment or element will now be spread over a length corresponding to one complete circumference of the path 10. The duration of this element therefore has been doubled and each frequency in it will have been halved so that its band extends from substantially zero to 2,500.

It is to be observed that when the element A has made one complete revolution it skips to the beginning of the path 10, and the portion of the message which at that moment occupies the path will be omitted so far as transmission to L_1 is concerned. As a result there will appear upon this line L_1 alternate elements of the original message, the frequencies f having been reduced to $f/2$. Although half of the message has thus been skipped, the elements which have been picked up by the device A have had their duration doubled, and therefore, these prolonged elements will follow each other with no appreciable blank intervals.

In order that the whole message shall be preserved, I provide in this invention a second pick-up device B, similar in every respect to the device A, and adapted also to rotate in the same manner but displaced by an angle of 180 degrees. This element B is connected by suitable contacts to a line L_2, and it will be apparent that by virtue of its position with respect to A, it will pick up the elements of the message which are skipped by A, and there will thus appear on the lines L_1 and L_2 fragments or elements of the original message, the frequency band width for each of these fragments being one-half of that normal to a speech signal. This has been indicated on these lines by the legend O—F/2, where it is understood that F is the maximum frequency considered in the speech signal.

In order to maintain the integrity of these two groups for later composition it is now necessary to shift the frequency band of at least one of the groups, thus placing it in a different portion of the frequency spectrum. This I may accomplish in my invention by modulating one of the groups, such as that arriving on the line L_1, to a carrier frequency. In the figure then there is shown a modulator M which is supplied by a sustained carrier frequency F/2 from an oscillator O. The output of this modulator is then permitted to pass through a band pass filter which transmits the higher side band extending, as is obvious from F/2 to F. The waves from the two paths may now be superposed and transmitted to a remote station, and it will be seen that the signal from the line L_2 occupies the lower half of the frequency band of the original message, whereas the signal from the line L_1 occupies the upper half of the original frequency band. In this circuit it may be desirable to place a wave filter 15 which transmits a band extending from zero to F.

It will now be seen that there is sent out on the transmission line a signal made up of the original message chopped into sections, and these sections altered as to frequency and superposed, the whole resulting in a wave so distorted as to be beyond recognition with ordinary receiving apparatus. In Fig. 2, however, there is shown a receiving station R adapted to co-operate with the transmitting station T to correct for this distortion. To this end there is introduced in the path of the signal a band pass filter 16 adapted to pass frequencies from O to F/2, such signals passing over the path L_2' and through suitable contacts to a recording device A′. A band filter 17 is also introduced in the circuit, this filter being adapted to pass all frequencies from F/2 to F. Since it is necessary to bring this band of frequencies to its demodulated condition, it is shifted by a demodulating device DM which is supplied by the incoming signal and by an oscillator of frequency F/2. A band pass filter 19 is then supplied, adapted to pass one side modulation band only, this being the band extending from zero to F/2, after which the resultant wave passes over the line L_1' through suitable contacts to recorder B′.

The recorders A′ and B′ are parts of a converter which is similar to the converter of the transmitting station T and consists of a path 20 adapted to receive and propagate impulses from the recorders A′ and B′. Consideration of this figure will make it evident that if the velocity of propagation of the wave in the path 20 is V, and the rotation of the elements A′ and B′, which are 180° apart, is in the same direction and numerically equal to V/2, then the frequencies transmitted by the path 20 to the line LE will be double the frequency of the wave coming in on the recorders, and therefore, of normal signal frequency. It will be seen also that each element of signal given to the line LE by A′ will be of half duration only, so that gaps will occur between each element.

The time relationship, however, of B′ with respect to A′ may be made such that the elements brought in by B′ will fall in these gaps and a continuous message will therefore result, this message being a reproduction of the original message coming in on the line LW. In order, however, to obtain this time relationship, it is necessary that the arms A′ and B′ shall rotate at exactly the same rate as the arms A and B; in addition it is necessary that the arms A′ and B′ shall be in phase with the arms A and B, due allowance being made for the time of transmission of the signal from the path 10 to the path 20. In other words, the two rotating arms must be run in synchronism, and for this purpose any of the well-known synchronizing means may be used.

In the above description it is stated that the oscillation of Fig. 1 shall give the frequency F/2. It may equally well be set to give the frequency F, in which case the lower side band extending from F to F/2 would be preserved for transmission by the band filter. In this event also the oscillator of Fig. 2 should be run at the frequency F in order to yield the restored signal fragments. It will be noted that the lower side band carries with it frequency in version and thus even greater confusion in the distorted wave with accompanying greater secrecy.

While this invention has been described in terms of halving and doubling the frequency band width, it is to be understood that this is for simplicity in the description only and that the invention is not to be limited to any such factor, but that the rotating parts of the converters may have a velocity bearing any desired relation to the velocity of propagation along the paths 10 or 20.

The paths 10 and 20 have been described in general terms only, this for the reason that they may take on a variety of forms such as are mentioned and described in the application of French and Zinn and in my application, both referred to above. Specifically, however, the converters may take on the form shown in Figs. 3 and 4, the first of these being suitable for a transmitting station and the second for a receiving station. Referring more particularly to Fig. 3, for example, the incoming wave from the line LW may be connected to a magnetic recorder comprising a coil 30 adjacent to an iron or steel tape or wire 31, moving with any desired velocity V and in part passing around a circular path. At the center of this circular path may be mounted an arm carrying reproducing devices A and B and rotating in the same direction as the tape at any suitable velocity such as V/2. Under these conditions the coils A and B will pick up elements of the message and transfer them to the lines L_2 and L_1, in the manner described in connection with Fig. 1.

Referring to Fig. 4, the separated received signal fragments coming over the lines L_2' and L_1' will pass to the recording coils A′ and B′ which are synchronously rotated about the center of a circle consisting of an iron or steel wire or tape 20. This tape or wire 20 should be traveling in the same direction as that of the recorders A′ and B′, and to follow the illustration thus far given, with a velocity twice that of the velocity of the recorders. The wire tape, with its impressed signal, now in undistorted form, may pass under a reproducer 40 which picks up the signal to transmit it over the line LE. In both Figs. 3 and 4 it will be necessary to restore the magnetic tape or wire to normal condition, and magnetizing means 32 and 42 may be provided for this purpose, or if preferred, the direct current sources may be replaced by A. C. sources as indicated by the dotted lines.

Still another form which the paths 10 and 20 may take is shown in Fig. 5. Here the transmission line LW comprises a pair of conductors which are connected to a retarding transmission path represented as a pair of concentric conductors, the further ends of these being connected to a network of a character to properly terminate the line, thus permitting propagation of the wave in one direction and yielding no reflection. Obviously the pick-up devices will be of appropriate type and the time relations given in connection with Figs. 3 and 4 would apply.

Instead of the moving tape of Figs. 3 and 4, it is apparent that any moving record with suitable pick-up devices may be used. One might, for example, use a photographic record or a phonograph record in a number of ways which will be obvious to those skilled in the art.

While the invention has been described in connection with a wire transmission circuit, it will be apparent that it may be used in other cases also, such as radio transmission. It would be obvious, for example, that one might take the distorted signal at the transmitting station T, just prior to its entering the filter 15, and use it to modulate a carrier frequency for radio transmission, and that a corresponding demodulation could be introduced at the receiving station. Another way in which the invention may be applied to high frequency transmission is illustrated in Fig. 5, in which the original signal and a carrier frequency from an oscillator O_1 are together impressed upon a modulator M_1. A band pass filter may be introduced to permit the transmission of one side band only, and this side band obviously may be impressed upon a converter shown schematically at 51 and partaking of the properties of the converter at 10. The one group of waves could then be impressed directly upon an antenna 52, and the other group, after modulation in a modulator M_2 with which there is associated a modulator generator O_2, could then be impressed upon an antenna 53, the carrier frequency for this second antenna bearing any desired relation to that of the antenna 52. The two antennæ could radiate on the same carrier frequency p, the one transmitting one side band from p to $p-F/2$ and the other band adjacent to it from p to $p+F/2$. In this case also a single antenna could be used and the two portions separated by suitable filters at the receiving station.

What is claimed is:

1. In a signaling system the method of obtaining secrecy, which comprises breaking the signal into elements, displacing alternate elements into one frequency band, displacing the remaining elements into another frequency band, superposing these on a transmission channel, receiving and separating the two portions, and restoring the elements to their normal frequency and normal time relation.

2. In a signaling system the method of obtaining secrecy, which comprises breaking the signal into elements, displacing alternate elements into one frequency band, displacing the remaining element into another frequency band adjacent thereto, superposing these on a transmission channel, receiving and separating the two portions, and restoring the elements to their normal frequency and normal time relation.

3. In a signaling system the method of obtaining secrecy, which comprises breaking the signal into elements, displacing alternate elements into one frequency band of narrower frequency width, displacing the remaining elements into another frequency band of narrower frequency width, superposing these on a transmission channel, receiving and separating the two portions, and restoring the elements to their normal frequency and normal time relation.

4. In a signaling system the method of obtaining secrecy, which comprises breaking the signal into elements, displacing alternate elements into one frequency band of narrower frequency width, displacing the remaining elements into another frequency band of narrower frequency width and immediately adjacent thereto, superposing these on a transmission channel, receiving and separating the two portions, and restoring the elements to their normal frequency and normal time relation.

5. In a signaling system the method of obtaining secrecy, which comprises breaking the signal into elements, displacing alternate elements into one frequency band of narrower frequency width, displacing the remaining element into another frequency band of narrower frequency width and immediately adjacent thereto, the bands together occupying the original frequency band, superposing these on a transmission channel, receiving and separating the two portions, and restoring the elements to their normal frequency and normal time relation.

6. In a signaling system the method of distorting the signal for the purpose of secrecy, which consists in interrupting the signal into elements of equal time length, reducing the frequency and the frequency band width of alternate elements to occupy a lower portion of the normal signaling frequency band, increasing the frequency and reducing the frequency band width of the remaining elements to occupy an upper portion of the normal signaling frequency band, superposing these on a transmission channel, receiving and separating the two portions, and restoring the elements to their normal frequency and time relation.

7. In a signaling system the method of distorting the signal for the purpose of secrecy, which consists in interrupting the signal into elements of equal time length, reducing the frequency and the frequency band width of alternate elements to occupy a lower half of the normal signal frequency band, increasing the frequency and reducing the frequency band width of the remaining elements to occupy an upper half of the normal signaling frequency band, superposing these on a transmission channel, receiving and separating the two portions, and restoring the elements to their normal frequency and time relation.

8. In a signaling system the method of obtaining secrecy, which comprises interrupting the signal into elements of equal time length, reducing the frequency and the frequency band width of alternate elements to occupy the lower half of the normal signaling frequency band, increasing the frequency and reducing the frequency band width of the remaining elements to occupy the upper half of the normal signaling band frequency, superposing these on a transmission channel, receiving and separating the two portions of the resultant wave, increasing the frequency and the width of frequency band of the one portion to normal, decreasing the frequency and increasing the width of frequency band of the other portion to normal, and restoring the elements to normal time relation with respect to each other.

9. In a signaling system the method of obtaining secrecy, which comprises interrupting the signal into elements of equal time length, reducing the frequency and the frequency band width of alternate elements to occupy the lower half of the normal signaling frequency band, modulating the remaining elements to a carrier frequency and reducing its frequency and frequency band to occupy the upper half of the normal signal-

ing frequency band, superposing these on a transmission channel, and restoring the elements to their normal frequency and normal time relation.

10. In a secrecy signaling system a transmitting station, a source of signaling current, means at said station for breaking said signal into elements and for decreasing the width of the frequency band of each element, means for transferring alternate elements to a frequency band different from that of the other elements, a receiving station, and means thereat for restoring the distorted signal to normal condition.

11. In a secrecy signaling system a transmitting station, a source of signaling current, means at said station for breaking said signal into elements and for decreasing the width of the frequency band of each element, means for modulating alternate elements to a frequency band different from and adjacent to that of the other elements, means for superposing the modified alternate elements for transmission, a receiving station, and means thereat for restoring the distorted signal to normal condition.

12. In a secrecy signaling system a transmitting station, a source of signaling current, means at said station for breaking said signal into elements and for decreasing the width of the frequency band of each element, means for modulating the alternate elements to a frequency band different from and adjacent to that of the other elements, means for superposing the modified alternate elements for transmission, a receiving station and means thereat for separating the two groups of elements, means for demodulating the modulated elements, and means for expanding the elements to normal frequency and bringing them into normal time relation.

13. In a secrecy signaling system a transmitting station, a source of signaling current, means at said station for breaking said signal into elements of equal time duration and of double duration and half frequency, separate paths for the alternate elements, a modulator in one path adapted to yield a modulated side band adjacent to the frequency band of the other group of alternate elements, means for superposing the two wave portions in transmission, a receiving station, and reciprocal means thereat for reconverting the received wave into the original signal.

In testimony whereof, I have signed my name to this specification this 11th day of August, 1926.

ALLEN CARPE.