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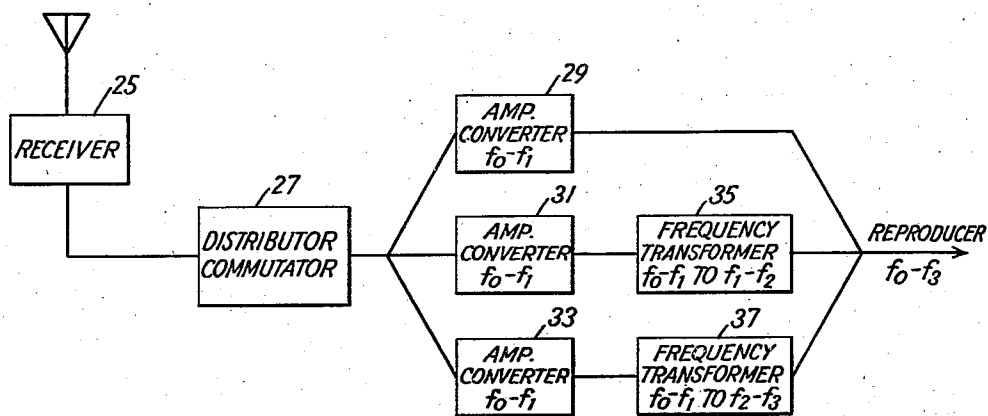
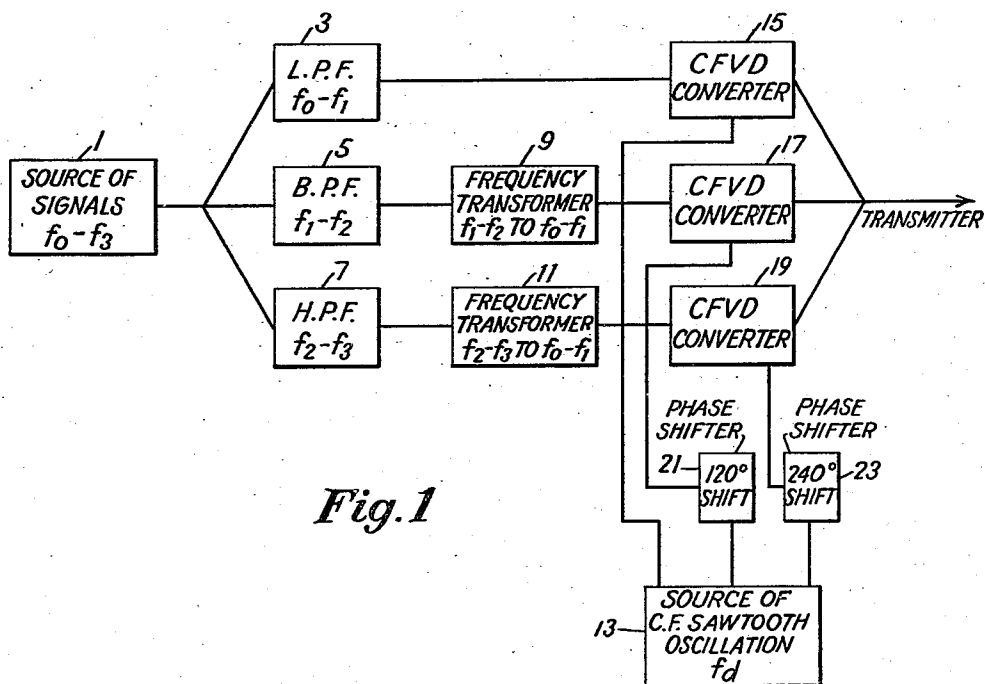
H. SHORE

2,408,692

SIGNALING SYSTEM

Filed April 29, 1942

4 Sheets-Sheet 1



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4 Sheets-Sheet 2

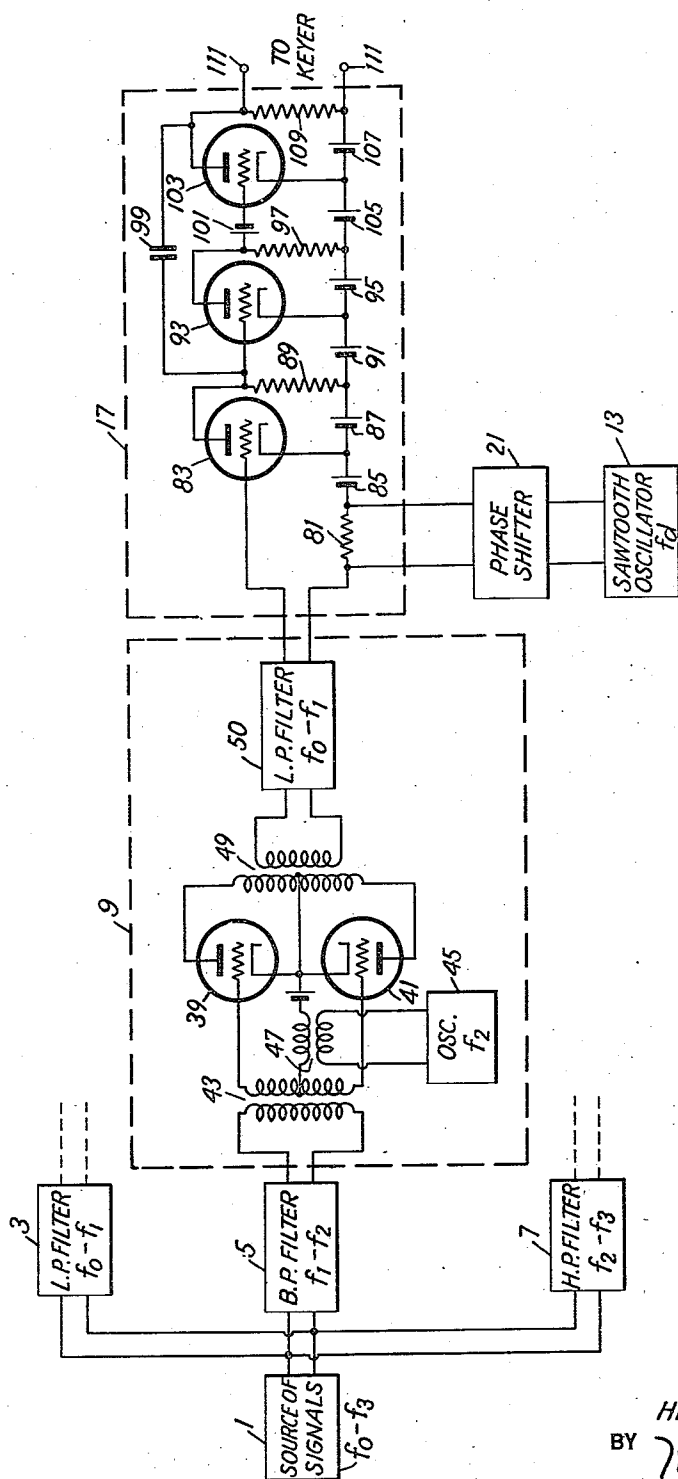


Fig. 3

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SIGNALING SYSTEM

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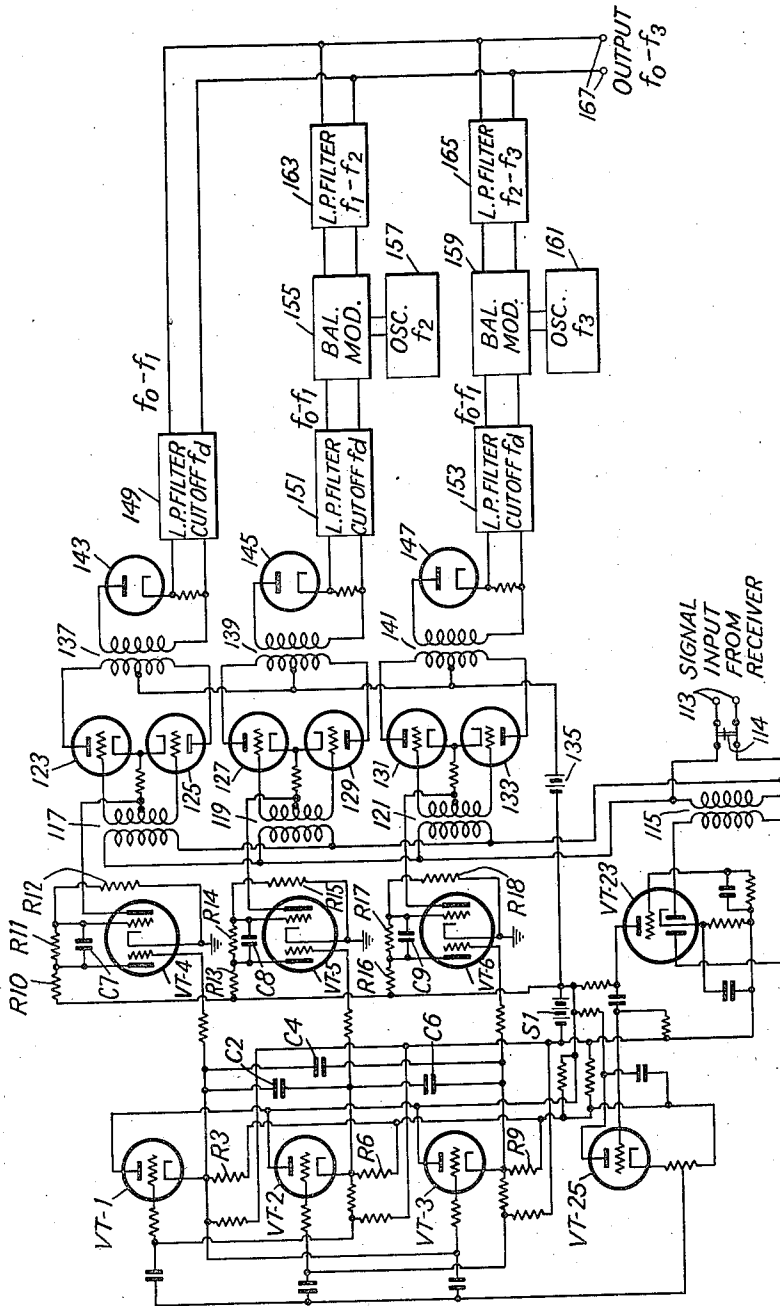


Fig. 4

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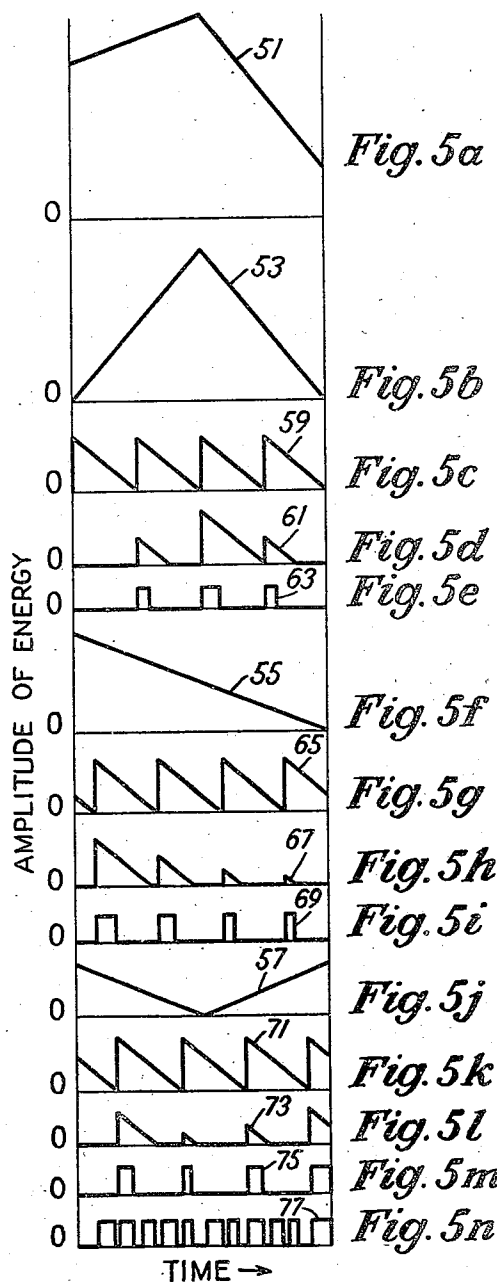
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2,408,692

SIGNALING SYSTEM

Filed April 29, 1942

4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,408,692

SIGNALING SYSTEM

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Application April 29, 1942, Serial No. 440,893

14 Claims. (Cl. 250—6)

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This invention relates to signaling systems, and in particular to methods of transmitting information by telephonic communications or by television transmission, in which there are incorporated features for enabling secrecy of the transmitted messages to be maintained.

In accordance with my invention I provide a transmission system suitable for use in television or telephone communications for maintaining secrecy utilizing well known circuit elements and at the same time providing means by use of limiters for obviating the difficulties of clear reception introduced by fading. In the method and apparatus used, the source of signals occupying a predetermined band width of frequencies is first separated into a plurality of discreet bands of frequencies. All but one of the bands of frequencies are thereafter transformed or displaced in the frequency spectrum so as to occupy the same band of frequencies as the unchanged band of frequencies. The resultant energy of each of the bands of frequencies is then individually converted into constant-frequency dot energy, the weight of dots being substantially proportional to the instantaneous value of amplitude of the energy within the band or channel. The inception of the marking interval for each dot of each channel is staggered, so that combining the outputs of a plurality of bands or channels, following their conversion into constant-frequency dots, there is obtained a signal whose dot frequency is as many times the original dot frequency of the constant-frequency variable-duration converters as there are channels involved. This signal is used to actuate the radio transmitter, or may be placed directly on the wire line for transmission.

At the receiver, the received signals are detected and the detected signals pass through a distributor commutator which distributes the constant-frequency variable-dot signals to their respective channels. The so-distributed dots are then converted back to a signal having variable amplitude, the instantaneous amplitude being proportional to the weight of the dot. The variable amplitude signals corresponding to the channels in which the frequency range was transformed are re-transformed back to occupy the same band of frequencies that they originally occupied at the transmitter. The signal energy from the three channels is thereafter combined to reproduce the original signal covering the original predetermined band of frequencies.

In order to prevent overlapping of the dots and to insure inter-channel stability of fre-

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quency, a single generator of sawtooth energy is provided. This is the source which is supplied to the constant-frequency variable-dot converter and, in one case, the energy is fed directly to the channel in which the frequency is not transformed. Energy from the sawtooth oscillator is also fed to each of the other converters with an appropriate phase shift introduced in each of the supply lines. The phase shift is equal to

$$\frac{2\pi}{N}$$

where "N" is the number of bands into which the original band of frequency is broken. Moreover, the maximum marking interval for each channel is restricted in terms of percentage to

$$\frac{100}{N}$$

where "N" is again the number of bands of frequency provided.

The advantages of such a system of transmission will be readily appreciated for it will be noted that in the first place, the television facsimile or telephone message is disguised in that there is no amplitude modulation but only time duration of the dots. Moreover, time duration of the dots ordinarily indicates telegraphic communication rather than the other modes of communication above enumerated. In addition, however, the displacement of the bands of frequency and the interleaving of their dot components requires that the dots be unscrambled and segregated into a number of groups. Even then the message remains unintelligible until all but one of the bands of frequency have been shifted in the frequency spectrum to occupy their original band, and all of the bands must thereafter be combined in order to provide a replica of the original message. There is also opportunity for rendering the system more secret by changing the widths of the bands of frequencies in a non-periodic fashion, and by interchanging the interleaving of the dots of each of the channels in a non-periodic fashion.

Thus it is the main object of my invention to provide a new method of transmitting intelligence.

Another object of my invention is to provide a new method and apparatus for transmitting telephonic and television signaling energy secretly.

Still another object of my invention is to provide a transmission system which affords secrecy by transforming certain bands of frequencies within the message and, moreover, converting

amplitude variations into time durations before transmission.

Yet again, it is an object of my invention to provide a receiver embodying a commutator and amplitude converter for transforming a message received in the form of dots of constant frequency to an amplitude varying signal representative of telephone or television transmission.

Other objects of my invention will become apparent to those skilled in the art upon the reading of the following detailed description, taken together with the drawings.

In the drawings,

Figure 1 shows, in block diagrammatic form, the essential elements of the transmitter embodying the principles of the methods and apparatus of my invention;

Figure 2 shows, in block diagrammatic form, a receiver embodying the methods and apparatus of my invention;

Figure 3 shows, in schematic form and in somewhat more detail, one of the channels of the transmission system shown in Figure 1;

Figure 4 shows, in somewhat more detail schematically, the commutator distributor and other elements incorporated in the receiver useful with my system; and

Figures 5a-5n show the time relationship in graphical form of the input signal and the wave shapes of the currents passing through the various portions of equipment.

In Figure 1, a source of signals 1 is fed to a plurality of filters 3, 5 and 7, to separate the frequencies originally present in the source of signals into a plurality of frequency bands. The use of three bands will be assumed in describing the present invention although, obviously a different number of bands may be employed. Thus, if the source of signals includes frequencies between the limits of f_0 and f_3 , then the filter 3 may be a low pass filter, for example, passing the frequencies f_0 and f_1 . The filter 5 may be a band pass filter passing the frequencies between the limits of f_1 and f_2 , while filter 7 may be a high pass filter passing frequencies from f_2 and f_3 . Alternatively, all of the filters 3, 5, and 7 may be band pass filters. The output of the filter 5 is then fed to a frequency transformer 9 to change the range of frequencies between f_1 and f_2 to a range of frequencies lying between f_0 and f_1 , it being assumed that the range of frequencies f_0 and f_1 is equal to the same range of frequencies lying between f_1 and f_2 and those frequencies lying between f_2 and f_3 .

Likewise, the frequencies passed by the filter 7 are transformed by the frequency transformer 11 to have their range changed from f_2 to f_3 to a range lying between f_0 and f_1 . A source of sawtooth oscillations 13 feeds a constant frequency variable duration dot converter 15, and likewise feeds the constant frequency variable duration dot converters 17 and 19 through the phase shifters 21 and 23, respectively. In the assumed example, where the number of channels is taken at three, the phase shifter 21 introduces a shift of 120° of the sawtooth oscillation, while the phase shifter 23 introduces a phase shift of 240° . In general, if the number of channels is " n " then the phase shifters will provide a shift of

$$\frac{2\pi k}{n}$$

where " k " is an integer less than " n " and " n " is the number of channels. By introducing the phase shifts between the sawtooth oscillator and

the CFVD converters, the outputs of the converters 15, 17 and 19 occur sequentially and the inception of each dot from the converter is spaced a constant time interval between successive dots. The CFVD converter may take the form shown in the Shore et al. Patent No. 2,083,245, and is shown schematically at the right hand side of Figure 3. The operation of the circuit will be described in somewhat more detail in describing Figure 3.

In order to facilitate an understanding of the operation of the arrangement shown in Figure 1, reference is made to Figures 5a through 5n. In these figures the abscissa relates to the time, while the ordinate relates to the amplitude of the energy. In Figure 5a it will be assumed that the envelope of the signal energy from the source of signals which has a time variation shown in the curve 51 being made up of energy whose frequency components between the frequency limits f_0 and f_1 have a time variation shown by the graph 53 in Figure 5b, while the energy components lying between the frequencies f_1 and f_2 have a time variation shown in curve 55 of the Figure 5f and whose energy components lying between the frequencies f_2 and f_3 have a time variation shown by the curve 57 in Figure 5g. That is to say, the sum of the energy components varying with time as shown in the curves 53, 55 and 57, is shown by the curve 51 of Figure 5a.

Consider first the energy variation passing through the filter 3 and having a time variation shown by the curve 53 in Figure 5b. In the CFVD converter 15, fed with sawtooth oscillations from the source 13, the energy passed by the filter 3 will permit peaks of the sawtooth oscillations to pass, which are then converted into square wave dots, the weight of the dots being proportional to the amplitude of the peaks of the sawtooth wave passed. Thus, the sawtooth wave energy fed to the converter 15 is shown in Figure 5c. The peaks passed by the converter are shown in Figure 5d, and are proportional to the amplitude of the curve 53 shown in Figure 5b. The resultant peaks are thereafter converted into square dots having weights which are proportional to the peaks as shown in Figure 5e. It will be noted that no dot results for the first sawtooth wave since at this point the amplitude of energy as shown by the curve 53 is zero. At the midpoint the amplitude of the curve 53 is a maximum and as a result, the whole sawtooth wave is passed and accounts for a square dot, shown in Figure 5e, whose duration is just under one-third of the time interval required for one cycle of the sawtooth wave. Similarly, the energy passed by the filter 5 is shown by the curve 55 in Figure 5f. The sawtooth wave energy 65 is now displaced one-third of a cycle, as shown in Figure 5g, and the peaks passed by the converter 17, shown as the curve 67 in Figure 5h, upon conversion take the form of the square dots 69, shown in Figure 5i.

The energy from the filter 7, when combined with the sawtooth wave 71, displaced two-thirds of a cycle, provides, following conversion of the passed peaks 73, the square dots 75 of Figure 5m. Combining all of the dots from the three CFVD converters 15, 17 and 19, therefore provides keying impulses having the form shown in the graph 77 of Figure 5n. It will be noted that by restricting the maximum square dot duration to just under one-third of a cycle, no overlap of dots can take place, and consequently the transmitted dots may be segregated at the receiving point to reconstitute the original signal.

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The receiver shown schematically in Figure 2 comprises any conventional radio receiver 25 feeding a distributor-commutator 27, which merely segregates the dots into three groups, the first group comprising the dots numbered 1, 4, 7, 10 and so forth, the dots in the second group constituting those numbered 2, 5, 8, 11 and so forth, while the third group comprises the dots numbered 3, 6, 9, 12 and so forth. The dots of the first group are fed to the amplitude converter 29 and the amplitude converter may comprise, for example, a detector and a low pass filter whose cut-off frequency is substantially the same frequency as the frequency f_a of the sawtooth oscillator 13. As a result, all the components of the sawtooth oscillator are suppressed and only a DC component is present, whose instantaneous amplitude varies in accordance with the weight of the dots. The second group of dots from the commutator 27 are fed to the amplitude converter 31, which is similar to the converter 29, to produce an output having an amplitude variation proportional to the dot duration variation and whose frequency components will lie between the range f_0 and f_1 , the same range as that of the converter 29. Similarly, the third group of dots from the commutator 27 are converted into a DC current variation in the converter 33, and occupy the same range of frequencies, f_0 and f_1 , as that of the converters 29 and 31.

A frequency transformer 35 converts or transforms the frequency range f_0 to f_1 of the components from the converter 31 to components having a frequency range f_1 to f_2 , while the frequency transformer 37 converts the frequency components from the converter 33 so that they now occupy the frequency spectrum lying between the range f_2 and f_3 . Subsequently, the output of the converter 29 is combined with the outputs from the frequency transformers 35 and 37 so that the output now contains the original frequency components lying between the range f_0 and f_3 , the amplitude of these components being proportional to the original components of energy present in the source of signals 1.

For telephonic communication, the introduction of the phase shifts at the transmitter by the phase shifters 21 and 23 of Figure 1 will not introduce any noticeable distortion, as it is well known that in telephonic and sound reproduction, the relative phase between the different components is ordinarily undetectable by ear. For television transmission, however, the phase relationship between the various components is of considerable importance, and in this case suitable phase delay may be introduced in the outputs of the converter 29 and the frequency transformer 35 so as to make the total time delay of transmission and reception equal for all three channels.

In Figure 3 I have shown in somewhat more detail one of the channels of the transmitter, in order to illustrate the frequency transformer and the CFVD converter. In Figure 3, the elements corresponding to the elements shown in Figure 1 bear the same designation numerals. The source of signals 1 feeds energy to the band pass filter 5 so that the frequency components f_1 to f_2 are segregated and passed on to the frequency transformer 9. The frequency transformer 9 is merely a balanced-modulated and low pass filter. The balanced-modulator is of the well known Heising type, and comprises a pair of tubes connected in push-pull in their plate circuits and having

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its input circuit fed by energy from the filter 5 in push-pull to the grids of the tubes 39 and 41 through the transformer 43.

Energy from the oscillator 45, whose frequency coincides with the top frequency passed by the filter, is fed in series through the transformer 47 to the grids of the tubes 39 and 41. The output energy from the balanced-modulator is fed through the transformer 49 to a low pass filter 50, whose pass range is between the frequencies f_0 and f_1 .

As is well known, the balanced-modulator suppresses the frequency f_2 in the plate circuit, so that there is only present frequency components which are the sum and the difference of the frequencies from the filter 5 and the frequency from the oscillator 45. The sum frequencies, therefore, will lie between the frequencies f_2 plus f_1 and f_2 plus f_2 . The difference frequencies will lie between the range of f_2 minus f_2 and f_2 minus f_1 . If the filter 50 is chosen as a low pass filter, only the difference frequencies will be passed, and these frequencies will lie between f_0 and f_1 , since it was assumed that the band widths of each channel were equal and that consequently the frequency f_2 is equal to twice the frequency f_1 . The difference frequency f_2 minus f_1 is consequently equal to f_1 . Thus the frequency components passed by the filter 5 and lying between the frequencies f_1 and f_2 are transformed so that they now lie between the frequencies f_0 and f_1 , and consequently occupy the same band of frequencies as those passed by the filter 3.

The output of the filter 50 is fed to the CFVD converter 17, which comprises a tube 83 biased to cut-off 85, so that the sawtooth wave energy from the oscillator 13 passed through the phase shifter 21 and fed across the resistor 81 is just at the point of overcoming the bias on the peaks of the sawtooth wave. The energy from the filter 50 consequently, when connected in proper polarity, reduces the bias in accordance with the energy from the filter 50 provided by the filter 85, so that the peaks of the sawtooth wave will be passed in proportion to the amplitude of the energy from the filter 50.

As a consequence, there will appear across the plate resistor 89 triangular pulses whose amplitude is proportional to the instantaneous value of the energy from the filter 50. The time duration of the triangular pulses will likewise be proportional to the instantaneous amplitude of the energy from the filter 50 in view of the fact that the bases of similar triangles are proportional to the altitude of the triangles. The triangular pulses from the resistor 89 are then fed to a square wave amplifier comprising the tubes 93 and 103, which converts the triangular pulses, whose base and amplitude vary, to square wave dots of constant amplitude and whose duration is proportional to the duration of the triangular pulses. The square wave amplifier may be of the type disclosed in the Shore Patent No. 2,005,111. The output of square wave dots may then be fed to the transmitter from the terminals 111 connected across the output resistor 109.

In Figure 4 I have shown in somewhat more detail the receiving end of my new system, and incorporating a commutator-distributor, amplitude converters, the frequency transformers and the final output circuit. In Figure 4, the vacuum tubes VT-1, VT-2 and VT-3 comprise the distributor tubes actuated from the signal input of the receiver fed to the terminals 113. The activation of the commutator takes place by trans-

ferring the signals through the transformer 115 to the rectifier amplifier tube VT—23, which, in turn, activates the impulse tube VT—25. The incoming signals serve to operate cyclically and sequentially the tubes VT—1, VT—2 and VT—3 in synchronism with the incoming signals. The commutator is of the Shumard type described in the Shumard Patent No. 2,146,862, as well as in the article described "Some electronic switching circuits" in the May, 1938, issue of "Electrical Engineering" at pages 209-220. Consequently, a detailed explanation of the operation of the commutator circuit will not be given since these circuits are already well known. It is only necessary to point out that in operation only one of the three tubes of the commutator draws current at any instant, while the other two tubes are cut off.

Assuming that the incoming pulse has activated the tube VT—3, a positive pulse from the tube VT—3 is applied to the input grid of the limiter tube VT—6, the pulse being derived from the drop in potential across the cathode resistor R—9. As a result, plate current in the tube VT—6 flows through the resistor R—16, producing a potential drop which causes the grid of the second half of the tube VT—6 to become inactive with respect to its cathode. The inactive potential on this grid blocks the flow of plate current on the second half of the tube VT—6, reducing the potential drop across the resistor R—21 to zero. This permits the push-pull stage, comprising the tubes 131 and 133, to act as an amplifier for the incoming signal which is applied to the grids of these tubes through the transformer 121, since the cut-off bias previously on the grids and obtained from across the resistor R—21 has been removed. The amplified signal is thereafter passed through the transformer 141 to the rectifier 147, and the output obtained across the resistor 148 is fed to a low pass filter 153. The low pass filter 153 has a cut-off frequency of f_d so as to suppress the dot frequency components and pass only the D. C. components.

The D. C. components will vary in amplitude in accordance with the time duration of the dots and the variations of the D. C. component will have frequency components lying between the frequencies f_0 and f_1 . These frequency components are then transformed by a frequency transformer comprising the balanced-modulator 159 and the oscillator 161 in a similar fashion to that described in connection with Figure 3. The oscillator 161 has a frequency f_3 and consequently the sum and difference frequencies at the output of the balanced-modulator 159 will be f_3 plus f_0 , f_3 plus f_1 , f_3 minus f_0 , and f_3 minus f_1 . Remembering that f_3 is three times the frequency of f_1 , it will be readily apparent that passing the output of the balanced-modulator 159 through the low pass filter 165 will result in only those frequencies lying between f_2 and f_3 , passing to the output terminals 167.

The next impulse received will cut off the tube VT—3, and activate the tube VT—2, which in turn will provide an output from the low pass filter 163 to the output terminals 167 in the same fashion as described for the previous channel. Thereafter, the next impulse will pass through the channel activated by VT—1 to provide an output from the low pass filter 149 with frequency components lying between f_0 and f_1 . Since these frequency components already correspond to the associated channel at the transmitter, it is unnecessary to shift these in frequency,

so that no balanced-modulator is provided for this channel. The combination, therefore, of the output from the low pass filter 149 together with the outputs of the filters 163 and 165 will provide across the terminals 167 energy components whose frequencies will lie between the limits of f_0 and f_3 , that is to say, the identical frequency range of those of the original signals.

It is to be noted that in transmitting the square dots, the maximum duration of the dots was restricted to just under the time interval of one-third of the sawtooth period. This is necessary to insure that a space occurs between successive dots in order to properly actuate successive channels by the distributor-commutator. If the space between dots were omitted, it will be readily seen that switching of the channels could not take place since the sequential operation of the commutator depends on termination and initiation of the dots. For this reason, it is desirable to see that the bias of the CFVD converters is adjusted to just pass the peaks of the sawtooth wave, so that at all times there are transmitted dots of very light weight of say, for example, 1% of the time duration of one sawtooth oscillation.

It will be appreciated, of course, that it is essential that the incoming impulses activate the proper channel. This can be readily achieved by operating the switch 114, that is, to open and close the switch rapidly until the proper phase is obtained. Conversely, a phasing signal may be sent comprising a long dash, and the switch opened and closed until the proper tube operates, which will thereafter be kept in an operating position by the long dash.

From the above description, it, of course, will be apparent that many and varied modifications of the invention may be made without departing from the general principles described and outlined hereinabove, and I, therefore, believe myself to be entitled to make any and all of these modifications such as would suggest themselves to those skilled in the art to which the invention relates, provided, of course, that such modifications and changes fall fairly within the spirit and scope of the invention as set forth in the hereinafter appended claims.

Having now described my invention, what I claim is:

1. The method of signaling which comprises the steps of producing electrical signals having frequency components lying between two predetermined limits of frequency, separating the frequency components into a plurality of bands of frequency contiguous with each other, shifting all but one of the bands of frequency to occupy the same frequency range as the frequency range of the unshifted band of frequencies, converting each band of frequency components into constant-frequency variable-duration pulses and cyclically and sequentially transmitting pulses of each of the plurality of bands.

2. The method of reproducing signals transmitted in the form of sequentially transmitted pulses of constant amplitude and variable time duration representative of a single train of energy having frequency components lying between two predetermined limits of frequency which includes the steps of receiving the transmitted energy, distributing the received energy into a plurality of channels, converting the received pulse energy in each channel into variable amplitude energy, shifting the frequency range of the energy components in all but one of the channels, and com-

binning the shifted energy components with the unshifted energy components.

3. The method of signaling which comprises the steps of producing electrical signals having frequency components lying between two predetermined limits of frequency, separating the frequency components into a plurality of bands of frequency contiguous with each other, shifting all but one of the bands of frequency to occupy the same frequency range as the frequency range of the unshifted band of frequencies, converting each band of frequency components into constant-frequency variable-duration pulses, the duration of said pulses being substantially proportional to the amplitude of the energy within the respective bands of frequency, and cyclically and sequentially transmitting pulses of each of the plurality of bands.

4. The method of reproducing signals transmitted in the form of sequentially transmitted pulses of constant amplitude and variable time duration representative of a single train of energy having frequency components lying between two predetermined limits of frequency which includes the steps of receiving the transmitted energy, segregating said pulses into a plurality of groups, distributing the segregated groups into a plurality of channels, converting the pulse energy in each channel into variable amplitude energy, shifting the frequency range of the energy components in all but one of the channels, and combining the shifted energy components with the unshifted energy components.

5. The method of signaling which comprises the steps of producing electrical signals having frequency components lying between two predetermined limits of frequency, separating the frequency components into a plurality of bands of frequency contiguous with each other, shifting all but one of the bands of frequency to occupy the same frequency range as the frequency range of the unshifted band of frequencies, converting each band of frequency components into constant-frequency variable-duration pulses of energy, cyclically and sequentially transmitting said pulses of energy of each of the plurality of bands, receiving the transmitted energy, distributing the received energy into a plurality of channels, converting the received pulse energy in each channel into variable amplitude energy, shifting the frequency range of the energy components in all but one of the channels, and combining the shifted energy components with the unshifted energy components.

6. Signaling apparatus comprising means for producing electrical signals having frequency components lying between two predetermined limits of frequency, means for separating the frequency components into a plurality of bands of frequency contiguous with each other, means for shifting all but one of the bands of frequency to occupy the same frequency range as the frequency range of the unshifted band of frequencies, means for converting each band of frequency components into constant-frequency variable-duration pulses, and means for cyclically and sequentially transmitting pulses of each of the plurality of bands.

7. Signaling apparatus comprising means for producing electrical signals having frequency components lying between two predetermined limits of frequency, means for separating the frequency components into a plurality of bands of frequency contiguous with each other, means for shifting all but one of the bands of frequency to

occupy the same frequency range as the frequency range of the unshifted band of frequencies, means for converting each band of frequency components into constant-frequency variable-duration pulses, the duration of said pulses being substantially proportional to the amplitude of the energy within the respective bands of frequency, and means for cyclically and sequentially transmitting pulses of each of the plurality of bands.

8. Signaling apparatus comprising means for producing electrical signals having frequency components lying between two predetermined limits of frequency, means for separating the frequency components into a plurality of bands of frequency contiguous with each other, means for shifting all but one of the bands of frequency to occupy the same frequency range as the frequency range of the unshifted band of frequencies, means for converting each band of frequency components into constant-frequency variable-duration pulses of energy, means for cyclically and sequentially transmitting said pulses of energy of each of the plurality of bands, means for receiving the transmitted energy, means for distributing the received energy into a plurality of channels, means for converting the received pulse energy in each channel into variable amplitude energy, means for shifting the frequency range of the energy components in all but one of the channels, and means for combining the shifted energy components with the unshifted energy components.

9. Receiving apparatus for reproducing signals transmitted in the form of sequentially transmitted pulses of constant amplitude and variable time duration representative of a single train of energy having frequency components lying between two predetermined limits of frequency comprising means for receiving the transmitted energy, means for distributing the received energy into a plurality of channels, means for converting the received pulse energy in each channel into variable amplitude energy, means for shifting the frequency range of the energy components in all but one of the channels, and means for combining the shifted energy components with the unshifted energy components.

10. Receiving apparatus for reproducing signals transmitted in the form of sequentially transmitted pulses of constant amplitude and variable time duration representative of a single train of energy having frequency components lying between two predetermined limits of frequency comprising means for receiving the transmitted energy, means for segregating said pulses into a plurality of groups, means for distributing the segregated groups into a plurality of channels, means for converting the pulse energy in each channel into variable amplitude energy, means for shifting the frequency range of the energy components in all but one of the channels, and means for combining the shifted energy components with the unshifted energy components.

11. A signaling system comprising a source of signals having energy components whose frequencies lie between an upper and lower predetermined limit, a plurality of filters connected to said source of energy, a constant-frequency variable-duration dot converter connected to the output of one of said plurality of filters, a frequency transformer connected to each of the other of said plurality of filters, a constant-frequency variable-duration dot converter connected to each of said frequency transformers,

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a common source of sawtooth wave energy connected to all of said constant-frequency variable-duration dot converters, and means for combining the output of all of said converters to feed to a common transmission channel.

12. A signaling system comprising a source of signals having energy components whose frequencies lie between an upper and lower predetermined limit, a plurality of filters connected to said source of energy, a constant-frequency variable-duration dot converter connected to the output of one of said plurality of filters, a frequency transformer connected to each of the other of said plurality of filters, a constant-frequency variable-duration dot converter connected to each of said frequency transformers, a common source of sawtooth wave energy connected to all of said constant-frequency variable-duration dot converters, a phase shifting network connected in the connection from the sawtooth wave oscillator to each of the converters connected to a frequency multiplier, and means for combining the output of all of said converters to feed to a common transmission channel.

13. A signal receiver comprising means for receiving electrical signals in the form of sequentially transmitted pulses of constant amplitude and variable time duration representative of a single train of energy having frequency components lying between two predetermined limits of frequencies, a commutator for distributing the received pulses into a plurality of channels, a detector in each of said plurality of channels, an amplitude converter connected to each of said detectors, a frequency transformer con-

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connected to each amplitude converter but one, and means to combine the output from all of the frequency transformers with the output from the said one amplitude converter.

14. A signaling system comprising a source of signals having energy components whose frequencies lie between an upper and lower predetermined limit, a plurality of filters connected to said source of energy, a constant-frequency variable-duration dot converter connected to the output of one of said plurality of filters, a frequency transformer connected to each of the other of said plurality of filters, a constant-frequency variable-duration dot converter connected to each of said frequency transformers, a common source of sawtooth wave energy connected to all of said constant-frequency variable-duration dot converters, a phase shifting network connected in the connection from the sawtooth wave oscillator to each of the converters connected to a frequency multiplier, means for combining the output of all of said converters to feed to a common transmission channel, means for transmitting the combined output pulses, means for receiving the transmitted pulses, a commutator for distributing the received pulses into a plurality of channels, a detector in each of said plurality of channels, an amplitude converter connected to each of said detectors, a frequency transformer connected to each amplitude converter but one, and means to combine the output from all of the frequency transformers with the output from the said one amplitude converter.

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