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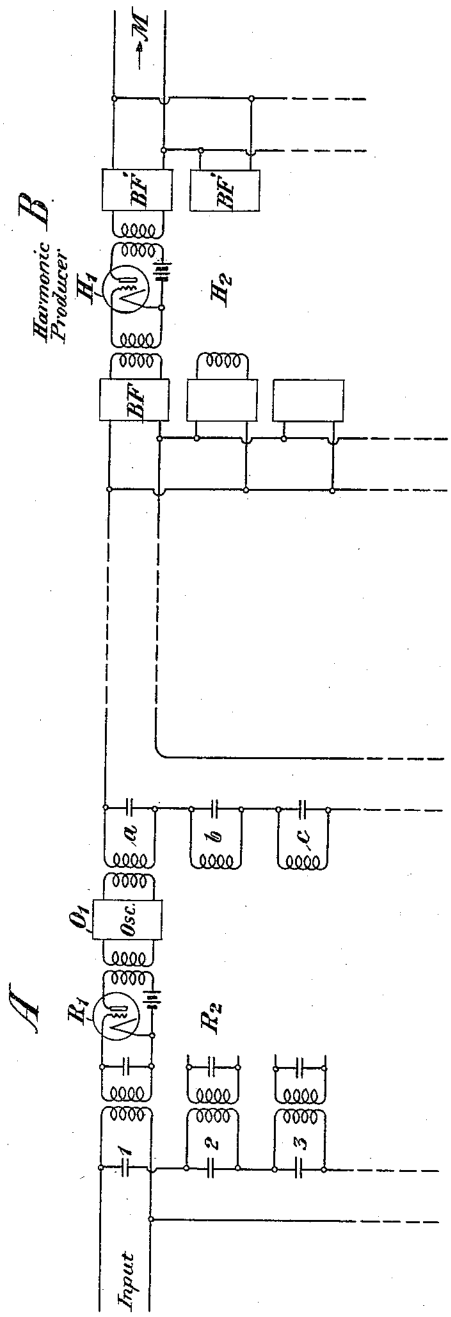

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COMPRESSION OF FREQUENCY RANGE

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This invention relates to a method and means for compressing the frequency range required for signaling. Its purpose is to make possible an increase in the number of channels of communication over any transmission system. Another purpose is to obtain a greater measure of secrecy in communication than is now commonly present.

It is well recognized that if a plurality of messages are to be transmitted simultaneously over any transmission medium, the frequency bands of the several messages should not overlap, and that if such overlapping does occur, there will be a loss in discrimination between the messages, with resultant undesirable effects. This limits, then, the number of simultaneous messages on a transmission line. If, however, the band of frequencies required for the messages can be diminished, then the number of messages possible without overlapping is correspondingly increased. In this invention I propose to narrow the band of frequencies corresponding to a given message. Suppose, for example, that the band required for certain signaling purposes runs from 6,000 to 10,000 cycles. If, then, each frequency in this message is reduced by some mechanism to a sub-multiple such as one-half of a frequency, then the whole message will be included in the band from 3,000 to 5,000 and is only one-half as wide as the original band. However, it will require a two-fold increase in time to transmit this modified message, and thus, so far as capacity of the transmission line is concerned, nothing has been gained. In order to obtain a reduction in the width of the band, as suggested above, without a corresponding increase of time, it will be necessary to leave out portions of the modified signal or make some other sacrifice equivalent thereto, all of which will result in a decrease in the quality of the message transmitted. In some cases, a certain amount of loss in quality would be permissible, still not resulting in such serious distortion as to destroy the intelligibility of the message.

One method for accomplishing such results is to provide a large number of selecting circuits to select narrow frequency bands from the signal band. The output of each selecting circuit may be rectified and used to control the output of a single frequency generator operating at some sub-multiple frequency of the original selected narrow band. The outputs of the plurality of generators may then be superposed and transmitted. At the receiving station, the component frequencies may be separated out and stepped up to the original range by any appropriate method. Further superposition of these restored frequencies would then yield a message which is substantially the equivalent of the original one.

It is apparent that in this process there has been the elimination of certain frequencies and therefore a certain distortion or loss of quality in the resultant message, for each of the original sub-bands which comprised a group of frequencies has been replaced by a single frequency. Evidently, the loss is less serious as the sub-bands are made narrower and narrower, and, as an ultimate goal, one might approach the condition where each single frequency may be represented by a sub-band. This, however, will require an exceedingly large number of selective circuits and controlled generators, and, as a practical matter, it would be desirable and satisfactory to reduce the number of selective circuits to the point so that the average frequency of any one sub-band shall be removed from the average frequency of the adjacent sub-bands by an amount not exceeding the minimum interval in frequency which can be distinguished by the ear. In the musical scale the normal ear can not readily distinguish an interval of less than one-quarter tone. Such an interval, as is well known, is given by the twenty-fourth root of 2 and corresponds to a relative change in pitch of about 3%. If the message in question lies in the normal speech range and extends from 350 to 2,800 cycles, this would correspond to seventy-two individual frequencies separated by one-quarter tone intervals. In actual practice, it would be possible to obtain fair reproduction with a substantially smaller number of frequencies.

The circuit diagram of the drawing illustrates one way in which the invention, as described above, may be carried out. Referring more specifically to that figure, there is shown a transmitting station A and a receiving station B joined by any suitable transmission medium. A message to be transmitted, which may be speech or otherwise, comes in on the input circuit, which latter comprises a plurality of selective circuits 1, 2, 3, etc., there being one such circuit for each band into which the original message is to be divided. Associated with each of these selective circuits are rectifier circuits R_1, R_2, etc., and these in turn control the output of generators O_1, O_2, etc. These generators may be of any desired form and very conveniently might consist of vacuum tube oscillators, each oscillator being adapted to give one frequency and that one frequency being a sub-multiple of the frequency of its controlling selective circuit.

The output of each of these oscillators may now be combined by any suitable means, such as the selective circuits *a*, *b*, *c*, etc., connected in series with the transmission line. Thus, there is transmitted over the line a group of individual frequencies which are placed as close together as proper tuning and requirements of modulation due to varying amplitude of each frequency will permit. The factor used for obtaining the sub-multiple frequencies will, of course, be adjusted to meet the requirements in view of the number of sub-bands into which the original message was broken and the closeness of placement which is permissible by normal tuning requirements.

At the receiving station B, this complex wave form is now broken up into its component frequencies by selective circuits. In the figure, these are shown as band filters, but any other appropriate method for selecting and separating the components will be satisfactory. The output of each of these selective circuits is used to control a harmonic generator or producer, these being shown in the drawing as vacuum tube circuits. The outputs of these harmonic producers are combined in the main channel M. It will be desirable, of course, to exclude from each harmonic producer all oscillations except the particular one which corresponds to the original frequency of the selected band which gave rise to the control of that particular harmonic generator. This can be accomplished by appropriate band filters BF′.

While this invention has been described specifically in connection with the figure of the drawing, it has a broader application than this. For example, it is apparent that in the usual message transmitted over the line there are more or less continuous changes in the wave form. If there were no such changes, that is, if a steady state condition were existing, there would be no need for the continuous transmission of component frequencies. Such a steady state condition could be communicated to the receiving end or reproduced at the receiving end by transmitting a message which contains a definition of the steady state condition together with start and stop impulses to indicate its duration. Since any signal may be considered as a succession of steady state conditions, it is evident that the transmission of intelligence may reside in the transmission of a succession of messages describing the steady state condition and indicating the change from one to the next. If the transmission of the signal in this latter form requires a smaller frequency band or a reduction in time, then a saving of frequency range or transmission time will have been achieved. This is what has been accomplished in the method described above.

Broadly, then, the invention will be seen to consist in transmitting the original signal to an analyzer (such as the series of tuned circuits of the figure) which will determine the frequency distribution of the signal at successive instants, and a new wave form is then produced and received at the remote station, the whole occupying, in the case cited, a narrow frequency range, carrying with it, of course, a certain amount of distortion, but permissible distortion.

As a modification of the specific methods shown in the figure of the drawing, the output of the analyzer device may be transmitted locally through a delay network and the output of this network added in reverse phase to the output of the analyzer which is impressed on the line. The reproduction of the signal at the receiving end would follow the inverse order and would add the received difference to the steady state, as defined by previous impulses.

What is claimed is:

1. The method of reducing the width of the frequency band required for signaling, which consists in breaking the message into narrow frequency bands, replacing each band by a related lower frequency, superposing and transmitting these frequencies to the receiving station, separating the components and translating each to its related higher frequency position.

2. The method of reducing the width of the frequency band required for signaling, which consists in breaking the message into narrow frequency bands, replacing each band by a substantially single frequency which is a sub-multiple of the average narrow band frequency, superposing these frequencies and transmitting the resulting wave, separating the components at the receiving station, translating each frequency in its original frequency position, and superposing them to give substantially the original message.

3. The method of reducing the width of the frequency band required for signaling,

which consists in breaking the message into narrow frequency bands, replacing each band by a substantially single frequency which is a sub-multiple of the average narrow band frequency, superposing and transmitting the resulting wave, separating the components at the receiving station, and stepping each frequency up to the approximate average frequency of the original band.

4. In a transmission signaling system, means for breaking the message to be transmitted into narrow frequency bands, a generator controlled by each such band adapted to generate a frequency which is a sub-multiple of the average narrow band frequency, means for superposing the generator outputs on the transmission line, means at the receiving station for separating the component frequencies and generating harmonics corresponding to the original band frequencies, and combining these to give the original message.

5. In a transmission system, means for breaking the message to be transmitted into narrow frequency bands, a generator controlled by each such band adapted to generate a frequency which is a sub-multiple of the average narrow band frequency, means for superposing the generator outputs on the transmission line, means at the receiving station for separating out the components, a harmonic generator for each component controlled in amplitude thereby and adapted to generate a harmonic of the control frequency lying in the original frequency band.

6. In a signaling system, a transmitting station, a plurality of selective circuits for dividing the message into narrow frequency bands, a rectifier associated with each selective circuit, a generator connected with each rectifier and controlled thereby, each generator being adapted to generate a wave of amplitude proportional to its rectifier output and of frequency which is a definite sub-multiple of the approximate average frequency of the originating band, means for superposing and transmitting the output of the generators, selective circuits at the receiving station to separate the component sub-frequencies, a plurality of harmonic generators each controlled by one sub-frequency and adapted to yield a wave of a frequency lying in the originating band in the signal message and of amplitude proportional to the amplitude of said band, means for eliminating other harmonics and for combining the selected output of the harmonic generators.

In testimony whereof, I have signed my name to this specification this 1st day of July, 1929.

ALLEN CARPE.