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SIGNALING SYSTEM

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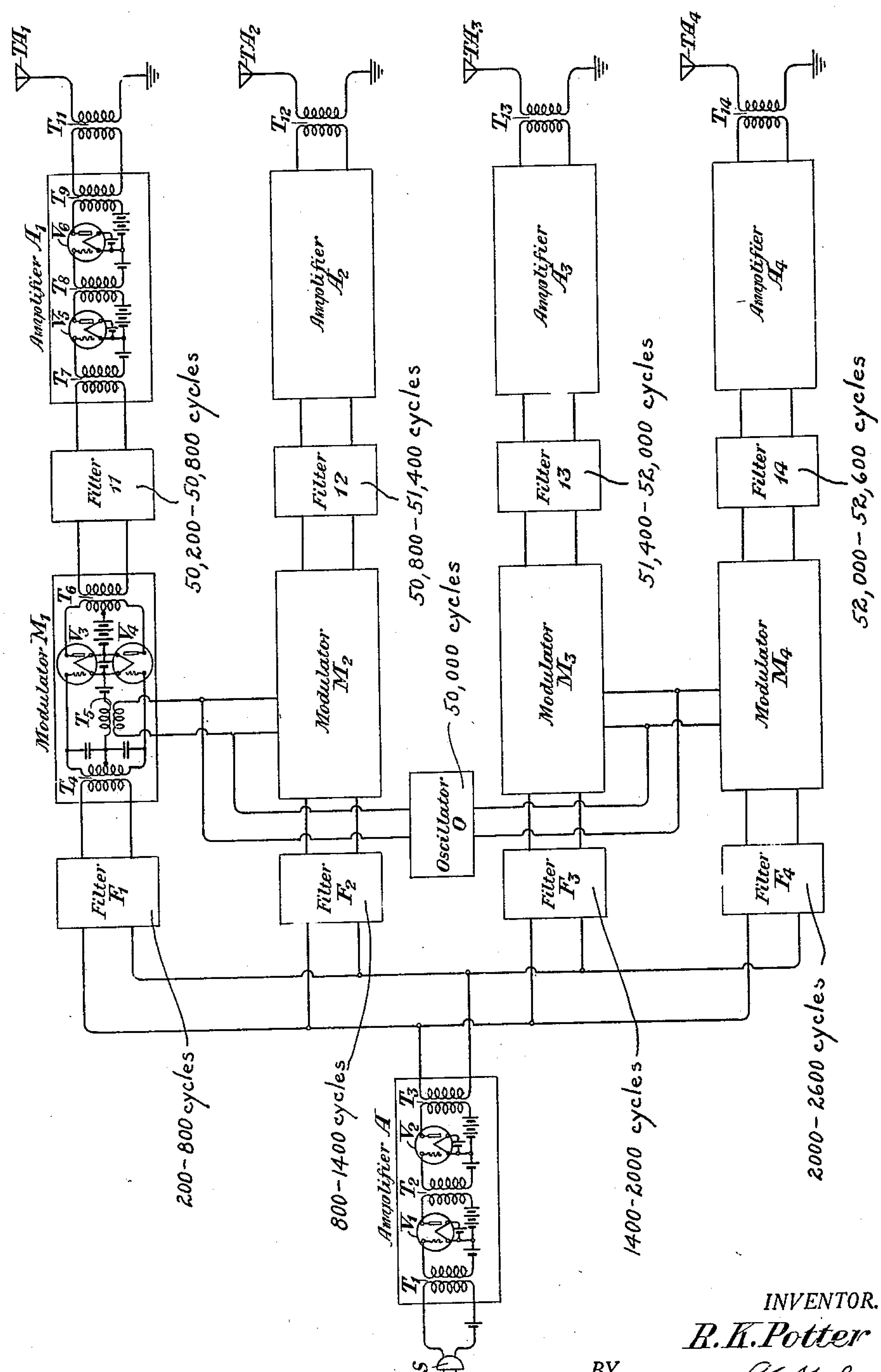

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SIGNALING SYSTEM

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This invention relates to signaling systems, and particularly to arrangements for signaling at high energy levels.

It has been determined by experiment that it is much more difficult to increase the power output of a radio transmitter from, for example, 100 kilowatts to, for example, 200 kilowatts, than it is to increase the power output from, for example, 5 kilowatts to 10 kilowatts. A point is finally reached at which it becomes practically impossible to increase the power output sufficiently and still provide suitable insulation. This is especially so in signaling systems of the short wave type, since in this type of signaling system, circuit dimensions must necessarily be limited.

There are other complications which limit the power to be derived from a signaling system. In a system in which a battery of vacuum tubes are connected in parallel, the difficulty of operating at high power is familiar to those skilled in the art. In signaling systems of the long wave type, the expense of huge antenna structures is very great. In signaling systems of the short wave type, the well-known troublesome inductive effects of powerful magnetic fields become apparent. In general, also, wherever the power output is increased, the breakdown hazard becomes greater and the margin of safety on insulation strength becomes reduced.

It is the primary object of the present invention to provide a system, such as a radio telephone system, for the transmission of signals at high power, which system may be designed to greatly overcome the difficulties mentioned hereinabove.

Briefly, the system described herein, for illustrative purposes, consists in generating signals and subdividing these signals into sub-bands which may be components of the same side band of a high frequency carrier wave, these sub-band components being transmitted through separate transmission channels. So far as the frequency spectrum is concerned, the same transmission channel is utilized as if a whole side band were radiated from a single source. In other words, the sub-bands compose a side band which occupies no more space in the spectrum than would be occupied by that side band if it were produced by modulating ordinary speech signals upon a carrier wave of a definite frequency. At a distant point such a side band may be received and combined with a single homodyning carrier wave, in a manner well known in the art, since, as has been stated hereinabove, the separately radiated bands or sub-bands composing the side band are all products of modulation of the same carrier wave. Interference, such as might be caused by the transmission of signals from a plurality of separate sources, is reduced to a minimum in this invention, as will be apparent from the description hereinafter following.

Assume, for illustration, that it is desirable to transmit a telephone conversation through space over a single channel of, for example, 3000 cycles in width and at a very high power level. Two transmitters, operating upon the same carrier wave, might be used in combination, the energy of the voice band representing the telephone conversation being suitably divided between these transmitters. An approximate division into equal frequency ranges may, if desired, be obtained by the use of the well-known electrical wave filters. If it becomes essential to divide the band representing the speech into sub-bands of substantially equal energy levels, each transmitter may then also be provided with, for example, a level regulator which may, if desired, be automatic in its operation, all of the regulators of the various transmitters then co-operating to equalize the power transmitted by the associated transmitters.

The various features and objects of this invention will be better understood from the detailed description hereinafter following, when read in connection with the accompanying drawing, showing one embodiment of the invention merely for the purpose of illustration.

Referring to the drawing, speech currents resulting from speaking into a microphone S are applied to an amplifier A of any well-known type, preferably of the vacuum tube type, as shown. Speech currents from the microphone S are then applied to a vacuum tube V_1 through a transformer T_1. The amplified energy is then applied to another vacuum tube V_2 through another transformer T_2. After being further amplified, the speech signals are then applied through a transformer T_3 to four sub-dividing electrical wave filters, F_1, F_2, F_3 and F_4. These electrical wave filters are preferably so designed as to pass adjacent portions of the speech frequency range. For example, filter F_1 may selectively transmit frequencies from 200 to 800 cycles; filter F_2 may transmit frequencies from 800 to 1400 cycles; filter F_3 may transmit frequencies from 1400 to 2000 cycles; and filter F_4 may transmit frequencies from 2000 to 2600 cycles, it being assumed that the essential speech frequencies are to be found within the range extending from 200 to 2600 cycles. This result may be accomplished by constructing each of these filters in the form of the well-known band filter, composed of a plurality of sections, as disclosed in a patent to G. A. Campbell, 1,227,113, dated May 22, 1917. It will be obvious that a different number of filters than the four illustrated may be used if desired, in which case the band widths of the respective filters will be suitably chosen to correspond with the number of filters used. It will be further understood that the filters already described herein are employed for the purpose of sub-dividing the speech frequency band into a plurality of sub-bands each of a relatively narrow frequency range. Each of these sub-bands, if received, may, of itself, normally be incapable of providing intelligible signals.

With the arrangement of the four filters shown in the drawing, it will be seen that the lowermost sub-band is transmitted by the filter F_1. The next higher sub-band, beginning substantially at the upper limit of the first sub-band, is transmitted by the filter F_2. Also, the next higher sub-band, beginning substantially at the upper limit of the frequency range of the filter F_2, is transmitted by the filter F_3, and the highest of the four sub-bands is transmitted by the filter F_4. These filters, therefore, transmit sub-bands which are adjacent in the frequency spectrum and, if combined, represent a band of signals corresponding to the speech signals originating in the microphone S.

The sub-bands transmitted by the filters F_1, F_2, F_3 and F_4 are then applied to corresponding duplex modulators M_1, M_2, M_3 and M_4, respectively. For illustrative purposes the normal path of transmission of one of the sub-bands, namely, the sub-band transmitted by the filter F_1, will be described herein in somewhat greater detail. The output of the filter F_1 is applied through a transformer T_4 to the input circuits of a pair of vacuum tubes V_3 and V_4, which are in push-pull relationship. An oscillator O transmits current of a carrier wave through a transformer T_5 to the branch common to the input circuits of the vacuum tubes V_3 and V_4. The output circuits of these vacuum tubes are in parallel relationship with respect to a common plate battery, these output circuits being connected through the primary of a transformer T_6. Inasmuch as modulator M_1 is supplied by a wave of a carrier frequency by means of the oscillator O, and is also supplied with a sub-band, such as is transmitted by the filter F_1, there will therefore be produced two side bands, each resembling the sub-band, though raised in the frequency spectrum, as is well known in the art. The modulator M_1 may be of the general type disclosed in a patent to J. R. Carson, 1,343,306, dated June 15, 1920. The oscillator O may, of course, be of any well-known type, preferably of the vacuum tube type, such as is shown and described in the patent to R. V. L. Hartley, 1,356,763, dated October 26, 1920 and it may produce current of any frequency as, for example, 50,000-cycle current.

It will be apparent that the sub-bands transmitted by the filters F_2, F_3 and F_4, are similarly applied to modulators M_2, M_3 and M_4, respectively, and that these modulators are also supplied by current of a carrier wave from the same source, i. e., oscillator O, so that there may be similarly produced for transmission two side bands corresponding to each sub-band. Accordingly, two side bands are transmitted by each of the modulators M_2, M_3 and M_4.

The modulators M_1, M_2, M_3 and M_4 are connected to filters F_{11}, F_{12}, F_{13} and F_{14}, respectively, each of these filters preferably having a band width substantially the same as the band width of the filter in the same transmission path. In other words, the band of frequencies transmitted by each of the filters F_{11}, F_{12}, F_{13} or F_{14}, is substantially equal in width to the band of frequencies freely transmitted by the corresponding filter F_1, F_2, F_3, or F_4. Filters F_{11} to F_{14}, inclusive, may, if desired, be of the type described in the aforementioned Campbell patent, each freely transmitting one of the side bands corresponding to one of the sub-bands resulting from modulation, while substantially suppressing the other side band corresponding to the same sub-band as well as all other intermodulation components. Each of these filters may, if desired, be designed so as to suppress the lower side band and freely transmit the upper side band, the upper side band being obviously of a width substantially equal to the width of the sub-band freely transmitted by the filter in the same transmission path, though raised in the frequency spectrum as a result of modulation.

Thus, filter 11 may selectively transmit frequencies from, for example, 50,200 to

50,800 cycles; filter 12 may transmit frequencies from 50,800 to 51,400 cycles; filter 13 may transmit frequencies from 51,400 to 52,000 cycles; and filter 14 may transmit frequencies from 52,000 to 52,600 cycles.

Filters F_{11}, F_{12}, F_{13} and F_{14} are connected to amplifiers A_1, A_2, A_3 and A_4, respectively. Each of these amplifiers may be of any well-known type, preferably of the vacuum tube type shown in some detail in the transmission path transmitting the side band corresponding to the lowest sub-band. The output of filter F_{11} is applied through a transformer T_7 to a vacuum tube V_5. After amplification by the vacuum tube V_5, the band of signals is transmitted to another vacuum tube V_6 through a transformer T_8. After being again amplified, the band of signals is impressed through a transformer T_9 upon the primary winding of a transformer T_{11}. It will be obvious that the amplifiers A_2, A_3 and A_4 may be of the same general type as the amplifier A_1, and that each of these amplifiers is employed to amplify the band of signals freely transmitted by the filter in the same transmission path. Moreover, the band of signals amplified by amplifiers A_2, A_3 and A_4 are also similarly impressed upon the primary windings of transformers T_{12}, T_{13} and T_{14}, respectively. The secondary windings of transformers T_{11}, T_{12}, T_{13} and T_{14}, are in series with transmitting antennas TA_1, TA_2, TA_3 and TA_4, respectively, so that the bands of signals impressed upon the primary windings of transformers T_{11}, T_{12}, T_{13} and T_{14} may be radiated through space by the transmitting antennas TA_1, TA_2, TA_3 and TA_4, respectively.

It will be apparent that by dividing the total power output of a signaling system into a plurality of elemental portions for their separate transmission to a distant station, which power output may also result from the modulation of voice frequency signals upon a carrier wave, the insulation difficulties above mentioned are greatly reduced, especially as the power output becomes considerably increased. The inductive effects, due particularly to excessive magnetic fields, are minimized, and this is so especially in the case employing carrier waves of short length for modulation. Moreover, the difficulties apparent in the use of a large number of vacuum tubes in parallel for the production of high power transmission systems are similarly minimized. Furthermore, a failure in the transmission through one of the transmission paths will not completely paralyze the transmission of signals as a whole. And furthermore, the electrical amplifiers and antenna structures can be more sharply tuned, so that there will be less energy absorption than if they were broadly tuned.

It will be obvious that the system described herein may be applied to a transmission system for secret signaling in which a normal speech band may be divided into a plurality of sub-bands, which may be inverted and rearranged as desired and then modulated upon the same carrier wave in accordance with the principles outlined in this invention. Clearly, one or more of said sub-bands may be radiated from separate sources or interchanged as desired, and then radiated through space, within the scope of this invention.

It will be apparent that while this invention has been described with particular reference to the sub-division of speech frequencies into a plurality of sub-bands of subtantially equal widths, the sub-bands may, if desired, be of unequal widths and these widths may be chosen so that the energies contained in the various sub-bands are approximately the same. Automatic level regulators may be inserted beyond the filters F_1, F_2, F_3 and F_4 in order to suitably divide the voice band into sub-bands of width depending upon energy levels.

While this invention has been shown and described in one particular embodiment, merely for the purpose of illustration, it is to be distinctly understood that the general principles of this invention may be applied to other and widely varied organizations without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. The method of transmitting a band of waves at a high energy level, which comprises dividing said band into a plurality of separate sub-bands, modulating the same carrier wave individually by said sub-bands so as to produce a plurality of side bands two of which correspond to each sub-band, and separately transmitting only the lower side bands of the various products of modulation as individual bands to a distant station.

2. In a high power short wave signaling system, the method of transmitting a band of waves corresponding to speech signals, which comprises dividing said band into a plurality of sub-bands, modulating each of said sub-bands upon the same carrier wave to produce corresponding, separate side-bands raised in the frequency spectrum, said side bands being adjacent to each other and together occupying the same width in the frequency spectrum as the speech band before division, and separately transmitting the latter side bands to a distant point each at a lower power level.

3. In a high power short wave signaling system, the method of transmitting speech signals through space, which comprises dividing said speech signals into sub-bands of substantially equal energy levels, separately modulating each of said sub-bands simultaneously upon a particular carrier wave, suppressing the products of each modulation except one side band corresponding to each sub-

band, and separately transmitting the unsuppressed side bands through space.

4. The method of transmitting speech signals at high energy levels, comprising subdividing the speech signals into sub-bands of frequency components, the components of each sub-band occupying a definite position in the frequency spectrum, simultaneously modulating a carrier wave by said sub-bands in channels individual to each sub-band, suppressing the unmodulated carrier component and one of the two side bands corresponding to each sub-band resulting from modulation, and separately transmitting the unsuppressed side bands corresponding to the sub-bands to a distant point.

In testimony whereof, I have signed my name to this specification this 18th day of October, 1927.

RALPH K. POTTER.