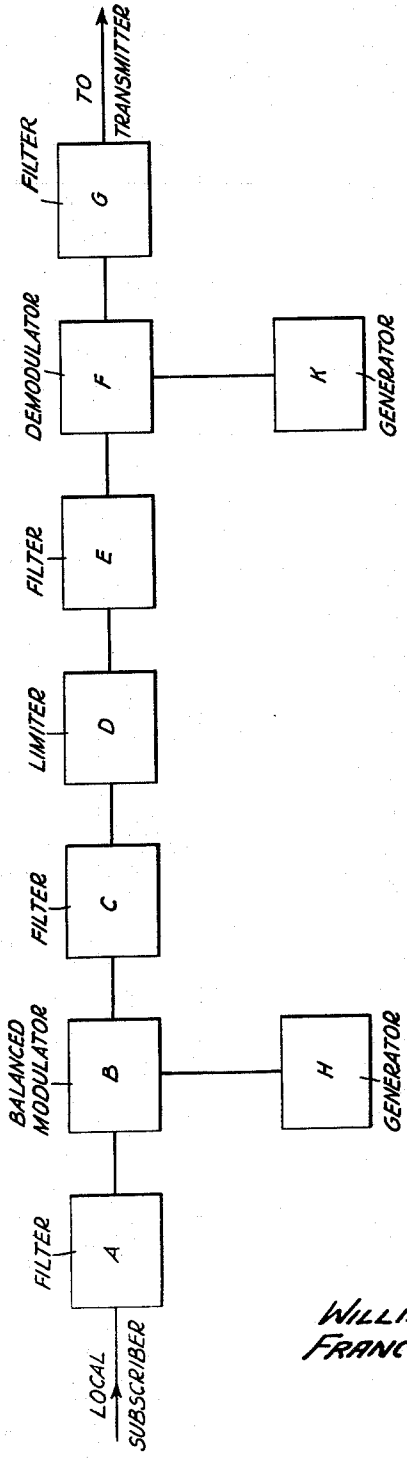
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RADIO TELEPHONE SYSTEM

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RADIO TELEPHONE SYSTEM

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This invention relates to radio telephone systems and more specifically to systems of the kind wherein a measure of secrecy is obtained by shifting the audio or speech signals from the audible range into a higher, supersonic range, the speech frequencies being modified either by inversion or by transposition or both of selected frequency bands. In such systems the inversion or transposition, or inversion and transposition, is ordinarily effected by modulating a supersonic frequency or frequencies with the speech frequencies, the resulting modulated supersonic frequencies being subsequently demodulated back to lower frequencies, in the audible range, before reaching the radio transmitter, the signals received at the far end of the channel, i. e., at the receiver, being subjected to the converse process. In such systems, therefore, the speech is transmitted over part of what may be termed the "secrecy" apparatus at supersonic frequencies between the speaker and the transmitter and again between the receiver and the listener.

In radio telephone systems, quite apart from whether said systems embody arrangements for securing secrecy or not, it is usual to provide means for regulating the "levels" of the signals transmitted to the radio transmitter from the "terminal", e. g., the subscriber, so that the modulation of the transmitter is confined within predetermined limits. Such regulation is, of course, effected for the purpose of maintaining the radio transmitter operating within limits between which said transmitter can operate efficiently and satisfactorily.

The present invention relates to systems wherein both limitation and the obtaining of secrecy as above set forth are resorted to and the said invention consists essentially in limiting the speech or other signal energy transmitted over those parts of the channel where the speech signals are in the form of the relatively high or supersonic frequencies above referred to. To put the matter in another way, a process for effecting radio telephony includes, according to the present invention, the steps of inverting or transposing or inverting and transposing selected speech frequency bands so that speech is transmitted between parts of the equipment at supersonic frequencies and limiting the speech energy which is transmitted at the said supersonic frequencies.

The present invention presents important advantages as follows:

Speech frequencies are such that the harmonics of the lower speech frequencies lie within the total band occupied by the speech frequencies as a whole. If, therefore energy limitation were, as is customary, effected as respects the audible frequencies themselves, the harmonics introduced would be transmitted as well as the fundamentals, and accordingly the listener at the receiving end would hear distorted speech. If, however, in accordance with the present invention, the energy limitation be performed at the supersonic frequencies the harmonics will no longer lie in the transmitted band and such distortion as exists will, therefore, be quite small and in general will be only that due to interaction between frequencies of high order and low energy content. Another advantage of the present invention lies in the fact that it will tend to reduce inaccuracies of control of level at the "terminal" but, of course, there is the slight disadvantage that the first modulator or equivalent valve of what may be termed the "privacy" system, i. e. the first valve after which the speech frequencies are inverted or transposed, must be able to handle a large range of input load.

Any means of frequency transposition or inversion or of transposition and inversion and any means of energy limitation known per se, may be employed in carrying out the present invention, but where, as will be usual, the energy limitation is effected automatically under the control of the speech signals themselves, it is preferred to effect this control, i. e., to effect the control of the supersonic frequency amplifier, in dependence upon sullable rather than in dependence upon instantaneous or "peak" power.

A transmitter embodying the present invention will now be described with reference to the accompanying schematic drawing. Speech from a local subscriber is passed through a filter A designed to pass the frequency band in question, for example, in the case of commercial telephony, speech, the band extending from 250 cycles per second to 2750 cycles per second. The output from the filter A is fed into a modulator circuit B to which is also passed oscillations from a local generator H whose frequency, for example, may be 13,000 cycles per second. The modulator may be of any convenient known type, for example, it may be a balanced modulator of the type disclosed in Carson's U. S. Patent No. 1,343,306, patented June 15, 1920. The output from the modulator B is fed through a filter C which in effect eliminates the lower side band, say, and the carrier, that is the locally generated oscillation, and, therefore, passes the band 13,250 cycles per second to 15,750 cycles per second. The output

from the filter is thus, practically, supersonic and consists of a single side band. This output is fed to a limiter D of any known and convenient type. For example, a limiter as described in British Patent #172,376, complete accepted Nov. 30, 1921, or in British Patent #157,209, complete accepted July 10, 1922, or British application #5373, filed in 1915, accepted March 23, 1916, or amplitude limiters of the type disclosed in Affel U. S. Pat. #1,511,015, patented Oct. 7, 1924, or de Bellescize #1,443,011, patented Jan. 22, 1923, may be employed. A preferred form of limiter known per se consists of three parts, (1) an amplifier, preferably a balanced amplifier incorporating so-called "variable mu" valves whose gain is controlled by alteration of grid bias, (2) an amplifier detector of high impedance input to which part of the output from C is fed, said detector being connected in cascade with the amplifier and having in its plate circuit a resistance, the arrangement being such that the volts drop across this resistance is dependent upon the input to the amplifier, and, (3) a second amplifier and second detector. The voltage drop across the resistance in the plate circuit of the first detector in the first amplifier detector is utilized as grid bias for the valves in the gain controlled amplifier and it will be appreciated that by suitable adjustment of the circuit constants the output from the gain controlled amplifier may be caused to remain constant, or increase or decrease with increase of input thereto over a wide range of variation. The input to the detector connected with the second amplifier consists of a part of the fluctuating lower frequency components of the plate current of the detector in the first amplifier detector, e. g., between 1 and 20 cycles per second so that the second detector is actuated by sullabic changes in speech power and not by sustained tones and the like. The output of the second detector is utilized to control the speed at which the gain control in the gain controlled amplifier is effected so that the limiter as a whole will permit sudden changes in input level to pass but will prevent persistently high or low levels to be maintained. In this way the result is achieved that the natural distribution of speech power is not substantially adversely affected.

The limiter D is followed by a second filter E designed to remove any substantial, first order, distortion terms produced by the limiter and to pass only those frequencies within the required band and the output from the second filter E is then dealt with and transmitted in the manner usual in secret transmission systems of the kind in question, e. g., the filter E may feed into a demodulator F, similar to the modulator B, connected to a second oscillator K so that the frequencies are changed to those actually required to modulate a wireless transmitter without changing the width of the band, e. g., the frequencies may be inverted or displaced, or both. To take an example consider an original speech frequency of S cycles per second and suppose the frequency of the first oscillator to be C_1 cycles per second. Then if the second oscillator K be of frequency C_1+3000 cycles per second the audible output at F will be $3000-S$ cycles per second. If the frequency of K be C_1+P cycles per second the audible output at F will be $P-S$ cycles per second. If P is greater than 3000 speech will be both displaced and inverted while if P is negative, speech will be displaced but not inverted. The demodulator F is followed by a filter G which eliminates unwanted demodulation products and filtered output passes to a radio transmitter, not shown.

The filter E following the limiter D is, as stated, designed to pass the useful band of frequencies which is, in the numerical example given, the band between 13,250 and 15,750 cycles per second. Now since the limiter D is essentially a non-linear arrangement it will produce distortion of the inter-modulation type and the first order inter-modulation terms will lie within the bands 0 to 2750 cycles per second and 26,500 to 31,500 cycles per second and since both these bands are outside that selected by the filter E the first order inter-modulation terms will be eliminated. The second order inter-modulation terms will however lie in the bands 39,750–47,250 cycles per second and 10,750–18,250 cycles per second and therefore the only distortion terms which will not be eliminated by the filter E are some of those due to second order difference terms, and incidentally those due to higher order terms of like type. For this reason the limiter D should be so designed in accordance with well known principles that the relative power of the distortion or demodulation products decreases rapidly with increase in the order of those products; in other words, the limiter D should be so designed that the difference products of second order and higher terms, carry an extremely small portion of the total power transmitted.

The limiter action may also apply to the case where the final speech frequency, after modulation to carrier frequency and demodulation, lies in the same spectrum and in original order of frequencies, i. e., is virtually unchanged.

Having thus described our invention and the operation thereof, what we claim is:

1. In a radio telephone transmitter a source of audible signals to be transmitted, a filter circuit connected to said source said filter circuit passing only a predetermined and useful range of said signal frequencies, a modulator connected to the output of said filter and to a local source of oscillations whereby the filtered signal frequencies are impressed on the oscillations to produce modulated energies, a second filter connected to the output of said modulator to pass one side band only of the output of said modulator, an amplitude limiter connected to the output of said last mentioned filter, and a second filter connected to the output of said limiter to pass a band corresponding to the aforesaid band wherein lie the desired signals which have been converted into the supersonic or higher audio frequency range, said last mentioned filter serving thus to eliminate first order terms of demodulation distortion introduced by the limiter.

2. Means for amplifying and translating modulating potentials for signalling purposes and for limiting the amplitude thereof, and for preventing harmonics of the lower frequencies of the signal band produced by said limiting action from mixing with the higher frequencies of said signalling band to produce distortion comprising, in combination a modulator connected with a source of modulating potentials and with a local oscillator of a frequency such that the side bands resulting from the combining of the local oscillations and the modulating potentials are sufficiently high to prevent harmonics of the lower side band frequencies from falling within the range of the upper side band frequencies, a filter circuit connected with the output of said modulator for selecting one of said side bands, an am-

plitude limiter connected with said filter, said limiter being energized by the amplitude of the selected side band to act on said side band frequencies to maintain the amplitude thereof constant in the output irrespective of changes of amplitude of the impressed side band, a filter circuit connected with said limiter and signalling means connected with said filter.

3. Means for amplifying and translating signalling potentials for signalling purposes and for limiting the amplitude thereof, and for preventing harmonics of the lower frequencies of the signal band produced by said limiting action from mixing with the higher frequencies of said signalling band to produce distortion comprising, in combination a modulator connected to a source of signal potentials and to a local generator, the frequency of the oscillations of said generator being such that the side bands resulting from the combination of the oscillations and the signal potentials in the modulator produces side bands of such frequencies that harmonics of the lower frequencies thereof fall above the upper frequencies of the side band in the frequency spectrum, an amplitude limiter coupled with the output of said modulator, said limiter being of the automatic volume control type, energized by power representative of the signal frequencies, and being tuned to a selected one of said side bands, a demodulator having an input coupled to the output of said limiter, said demodulator being also connected to a high frequency generator, and having an output which may be coupled to transmitting means.

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