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PREVENTION OF OVERLOADING IN SPEECH CIRCUITS

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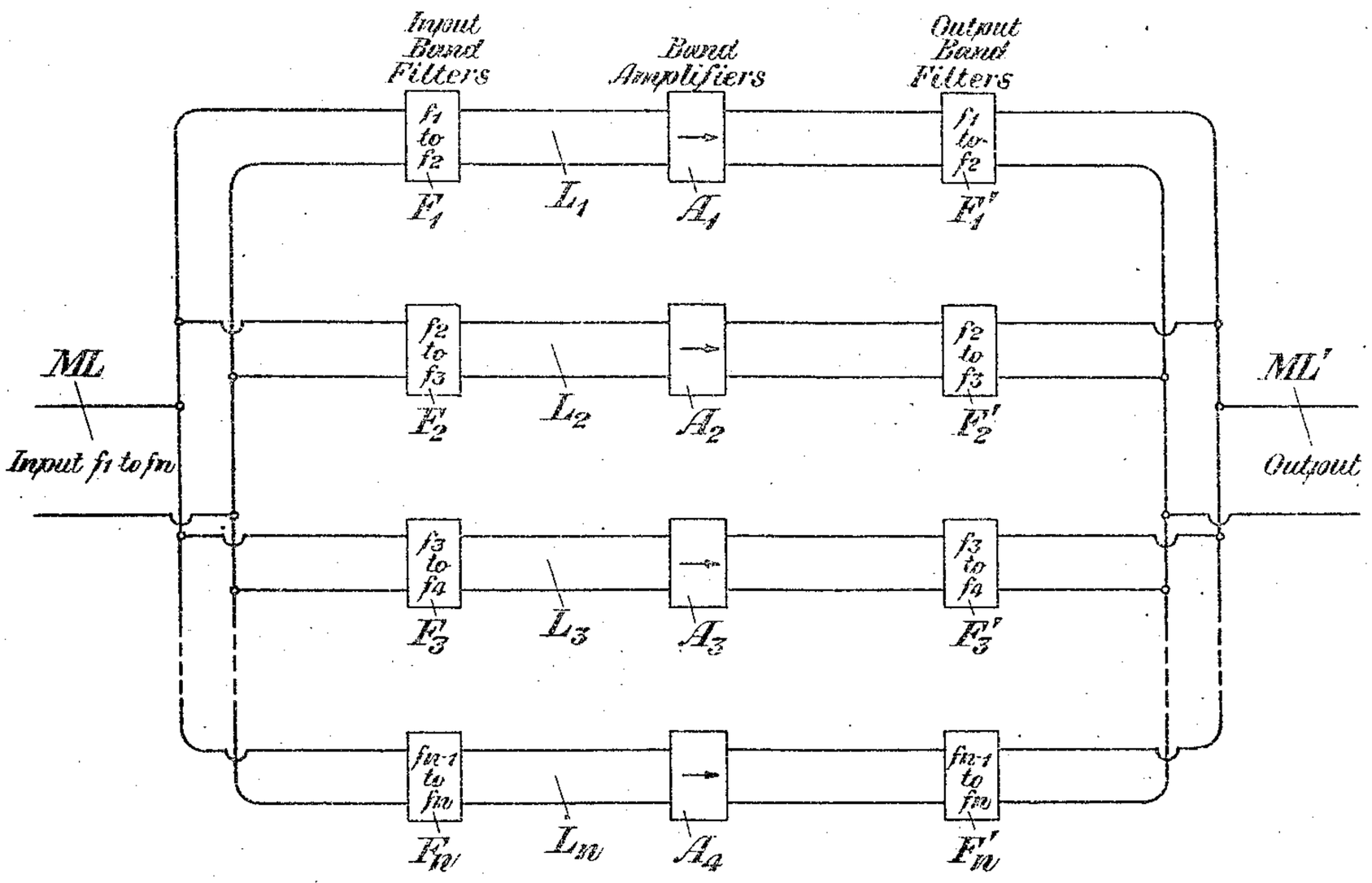

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PREVENTION OF OVERLOADING IN SPEECH CIRCUITS.

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To all whom it may concern:

Be it known that I, LLOYD ESPENSCHIED, residing at Hollis, in the county of Queens and State of New York, have invented certain Improvements in the Prevention of Overloading in Speech Circuits, of which the following is a specification.

This invention relates to transmission circuits, and more particularly to a method of and apparatus for preventing distortion effects due to overloading of vacuum tubes in such circuits.

In connection with the use of vacuum tubes in repeater and radio circuits, it is desirable to keep the volume of speech transmission below a value which would overload the tubes and cause distortion. Where the volume is subject to great variations, as is the case in connection with the pick-up of radio broadcast material, it is very important to control the volume that is applied to a vacuum tube. It has hitherto been the practice to take care of this matter through the manual adjustment of the volume applied to the tube by an operator who watches a so-called "level indicator."

The effect of overloading the vacuum tubes in a speech circuit is to produce distortion of the transmission. This distortion may be regarded as taking two general forms; (a) a chopping off of the peaks in the speech wave due to the current limiting characteristic of the tube (this action may also be regarded as one in which the various frequency components comprising speech are amplified to different degrees), and (b) the production of intermodulation frequencies due to the interaction of the component frequencies present simultaneously in the speech, these intermodulation frequencies arising owing to the fact that the amplifying circuit when overloaded is operating as a modulating device.

It has been proposed to employ the saturation characteristic of the vacuum tube as a means for limiting the power passing over a circuit. This may readily be accomplished to a certain extent in telegraphy due to the use of a single transmission frequency, but it cannot be practiced in telephony because, if the volume of the speech currents is sufficiently great to exceed the saturation point of the tube, the same kind of distortion will occur in the output circuit of the power limiting tube as results from the overloading of the amplifier tubes in their regular operation.

It is the purpose of the present invention to provide a method, and instrumentalities for practicing the method, which will permit of the transmission of telephonic currents through a power limiting tube without intermodulation of the frequencies, so that the volume transmitted to the amplifying or other tubes of the system will not overload such other tubes. In fact, if desired, the method may be used directly in connection with the amplifying tubes themselves to prevent the intermodulation due to the overloading of such tubes.

The invention may now be more fully understood from the following description thereof when read in connection with the accompanying drawing, the figure of which indicates schematically a circuit arrangement embodying the principles of the invention.

As already stated, distortion due to overloading may be considered as resulting from intermodulation in the overloaded tube between the various component frequencies and the voice transmission. Thus an 800-cycle component may modulate with a 1200-cycle component. In so doing not only are these two components reduced in amplitude, but new components are originated. Prominent among these components are the sum and difference terms (2000 cycles and 400 cycles) and their harmonics. The depreciation in quality is due in large part to these spurious components. There is also some distortion due to the cutting off of the peaks in the speech wave shape, but experiments have shown that considerable distortion of this type may be allowed to take place in a telephone circuit without affecting the articulation seriously. Consequently, if the depreciation in quality due to the intermodulation effect can be eliminated, it will be possible to obtain high quality transmission.

In order to accomplish this result, in accordance with the present invention the telephone band is divided by means of filters into a plurality of sub-bands, each sub-band being less than one octave in width. Thus,

if the voice band started with 100 cycles, the sub-bands could be chosen as follows:

Sub-band No.	Frequency limits	For example
1	f_1—f_2	100 to 180
2	f_2—f_3	180 to 320
3	f_3—f_4	320 to 580
4	f_4—f_5	580 to 1000
5	f_5—f_6	1000 to 1800
6	f_6—f_7	1800 to 3200
7	f_7—f_8	3200 to 5800

etc.

The figure of the drawing shows the manner in which these bands would be separately impressed upon a power limiting tube and then recombined to form the voice band. ML designates the transmission line carrying the voice band, and this line is divided into a number of branches L_1, L_2, etc., each provided with an input band filter such as F_1, F_2, etc., for the purpose of dividing the band transmitted by the line ML into a plurality of sub-bands, a different sub-band being transmitted to each branch. A vacuum tube amplifier will be included in each branch as indicated at A_1, A_2, etc. These vacuum tube amplifiers may take the place of the regular amplifier of the system or may be power limiting tubes for protecting the regular amplifiers occurring at later points in the system. In the output circuits of the amplifiers of the various branches additional filters such as F'_1, F'_2, etc., are provided for filtering out the intermodulation components, as will be described later. The several branches L_1, L_2, etc., are merged in the outgoing transmission line ML'.

To understand how such an arrangement overcomes intermodulation, it should be noted from the table above given that the highest frequency in any sub-band is less than double the lowest frequency, so that the lowest sub-component resulting from intermodulation of the components of the sub-band will be greater than the highest frequency, and the highest difference frequency resulting from intermodulation will be lower than the lowest frequency of the sub-band. For example, consider two components lying within the first sub-band, such as 120 and 150 cycles. These frequencies would pass through the filter F_1 and be excluded by all of the other channel filters. If overloading occurs in the tube A_1, the sum and difference frequencies would be 270 cycles and 30 cycles, respectively, and as they both lie without this band, neither will pass through the output filter F'_1. Likewise, the harmonics of 270 are all greater than 180, which is the upper limit of the band, and will not pass through the filter F'_1. The harmonics of 30 which fall below 100 and above 180 will also be excluded, although those falling within the band will not be eliminated. It is thus seen that practically all extraneous frequencies which may be produced can be kept out of the output circuit.

By the use of an arrangement such as that above described, the output resulting from recombining the sub-bands will always be of good quality independent of the volume input. For low input volumes the output volume will, of course, vary with the input, and the distorting action will not occur, but when any component of the input exceeds the volume level which the tubes in the various branches can handle, the volume output will cease to rise but will remain substantially constant at the maximum level. The arrangement therefore constitutes an automatic volume limiting device, and the organization illustrated in the figure may be inserted as a whole in any transmission system, including vaccum tubes used as amplifiers and the like, to limit the volume which will be transmitted to the tubes, or the arrangement may be substituted for any amplifier of the system, in which case the filters acting in combination with the amplifiers eliminate the undesired frequencies resulting from intermodulation due to overloading the amplifiers.

In any practical case it will be possible to reduce the number of subdivisions required by taking advantage of the fact that the lower frequency portion of the voice range contains most of the voice energy, and thus overloading would always occur as in the lower sub-bands. Another advantage of the arrangement is that it may be also used for equalization of the transmission at different frequencies. The gain of each of the vaccum tubes A_1, A_2, etc., may be adjusted in a well-known manner so that the gain of each amplifier may be so set as to compensate for the circuit losses at the frequencies involved.

It will be obvious that the general principles herein disclosed may be embodied in many organizations widely different from those illustrated without departing from the spirit of the invention as defined in the following claims.

What is claimed is:

1. The method of preventing distortion due to the intermodulation of component signal frequencies arising from the transmission over a transmission circuit of signal currents having amplitudes great enough to overload a translating device in the circuit, which consists in obtaining from the band of signal frequencies a band the upper limiting frequency of which is lower than the second harmonic of the lower limiting frequency, limiting the energy transmitted through a portion of said circuit to an amount less than the peak value of the band, thereby producing intermodulation components, selecting from the resultant frequencies a band of frequencies coinciding with the band transmitted, and suppressing

the intermodulation components lying outside said band.

2. The method of preventing distortion due to the intermodulation of component signal frequencies arising from the transmission over a transmission circuit of signal currents having amplitudes great enough to overload a translating device in the circuit, which consists in separating the band into a plurality of sub-bands, each having its upper limiting frequency less than the second harmonic of its lower limiting frequency, transmitting each sub-band through a separate path, limiting the energy transmitted through certain of the paths to an amount less than the peak value of the band, thereby producing intermodulation components, selecting from each path only the frequencies corresponding to the original sub-band, and combining the selected sub-bands to form a band corresponding to the original band.

3. In a signaling system, a transmission circuit including translating devices adapted, when overloaded, to produce intermodulation components, means to transmit over said circuit signal currents having peak amplitudes great enough to cause overloading of said translating devices, an arrangement to prevent the distortion due to such overloading comprising means to produce a band of frequencies from the original signal frequencies having an upper limiting frequency which is lower than the second harmonic of the lower limiting frequency, means to limit the energy of said band transmitted through a portion of said circuit to an amount less than the peak value of the band, thereby producing intermodulation components, and means to select from the resultant frequencies a band coinciding with the band originally produced, while suppressing intermodulation components lying outside said band.

4. In a signaling system, a transmission circuit including translating devices adapted, when overloaded, to produce intermodulation components, means to transmit over said circuit signal currents having peak amplitudes great enough to cause overloading of said translating devices, an arrangement to prevent the distortion due to such overloading comprising means to select from the band of signal frequencies to be transmitted a plurality of sub-bands, each having its upper limiting frequency less than the second harmonic of its lower limiting frequency, means to limit the energy transmitted by certain of said sub-bands, thereby producing intermodulation components, means for selecting from each energy-limiting arrangement a band corresponding to the original sub-band, and means for combining the selected sub-bands to form a band corresponding to the original band.

5. In a signaling system adapted for the transmission of voice currents, the energy of which fluctuates through a considerable range, and including vacuum tubes adapted to be overloaded when the signal energy exceeds a limiting value, an arrangement for preventing the distortion due to such overloading comprising a plurality of branch circuits, selective devices in each branch circuit for selecting from the normal signal band a sub-band, the upper limiting frequency of which is less than the second harmonic of its lower limiting frequency, a power limiting device in each branch to limit the energy in the branch, thereby producing intermodulation when the energy of the band exceeds the limit, and a second selective device in each branch for selecting from the resultant frequencies a band corresponding to the sub-band originally selected, thereby suppressing intermodulation components lying outside said sub-band.

In testimony whereof, I have signed my name to this specification this 18th day of September 1924.

LLOYD ESPENSCHIED.