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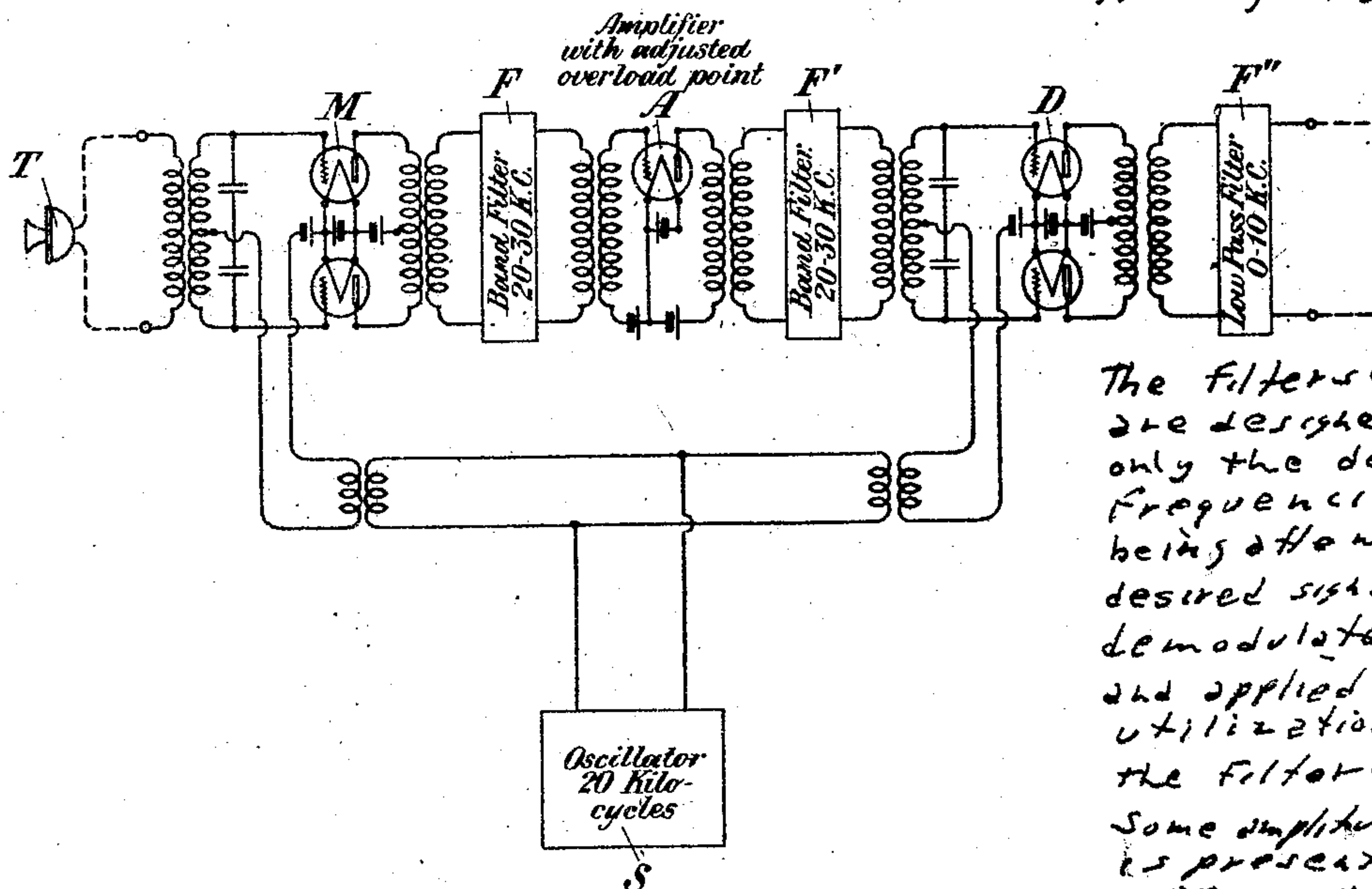
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H. A. AFFEL

PREVENTION OF OVERLOADING IN SPEECH CIRCUITS

Filed Sept. 19, 1924

Elimination or correction of frequency distortion due to intermodulation of various frequencies when the tube is overloaded. The speech signal at (T) is modulated by a frequency from (S) higher than any of the frequencies appearing in speech signal.



The filters (F) and (F') are designed to pass only the desirable frequencies, all other being attenuated. The desired signal is then demodulated by (D) and applied to a utilization device via the filter (F''). Some amplitude distortion is present but not sufficient to interfere with output signal.

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UNITED STATES PATENT OFFICE.

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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, HERMAN A. AFFEL, residing at Maplewood, in the county of Essex and State of New Jersey, 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 the circuit may be arranged so that the amplifying and chopping off action take place at a frequency which is above the highest frequency which is considered important in the transmission of speech. As illustrated in the drawing, this may be done by impress-

ing the speech currents originated by the transmitter T upon a modulator M preferably of the balanced tube type supplied with a source of carrier current S whose frequency may be, for example, about 20 kilocycles. The output circuit of the modulator M is supplied with a bank filter F which may be adjusted to suppress one of the side bands, the carrier component being suppressed by the balanced arrangement of the modulator. The resultant side band in the case illustrated is shown as covering a range of from 20 to 30 kilocycles. This modulated current is then led to the amplifier-saturation device A which may be either the regular amplifier of the system or may be a power limiting tube for protecting the regular amplifier (not shown) occurring later in the system. Where the tube A is a special power limiting device, it is so arranged that the saturation occurs at the desired point which will prevent the volume from exceeding the maximum volume which the amplifiers will transmit without overloading. As is well known, this saturation point may be adjusted by properly proportioning the size of the tube and properly adjusting the grid and plate batteries which energize its circuit. Where the tube A is merely the regular amplifier of the system, its overloading point is already determined, and the intermodulation components resulting from overloading will be suppressed, as will be described later.

It will be apparent that the voice band reaching the tube A has been elevated in the frequency spectrum to a point such that any modulation components, resulting from intermodulation of component frequencies corresponding to the original frequencies of the voice band, will lie without the range transmitted by the filter F.

The minimum sum frequency and the lowest harmonic will be 40 kilocycles, which is above the upper limit passed, and the maximum difference frequency will be 10,000 cycles, which is below the limit to be passed. Consequently, by providing a filter F' in the output circuit of the tube A, these intermodulation components may be suppressed and only the band between 20 and 30 kilocycles will be passed. The band which is transmitted may be impressed upon a demodulator circuit D preferably of the well known vacuum tube type and supplied by a homodyne frequency from the source S identical with that which was originally modulated. The output currents from the demodulator D may then be passed through a suitable low pass filter F'' thereby transmitting the original voice range but eliminating all higher components. If any amplifiers occur in the circuit beyond the filter F', they will be protected from overloading because the tube A will limit the power

transmitted whether the tube be a regular amplifier of the circuit or whether it be especially provided for limiting the power.

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 elevating the position of the signal band in the frequency spectrum so that the upper limiting frequency of the elevated band will be lower than the second harmonic of the lower limiting frequency of the elevated band, transmitting the band thus elevated, limiting the energy thus transmitted to an amount less than the peak value of the band, thereby producing intermodulation components, selecting from the resultant frequencies a band corresponding to the original elevated band, and restoring the selected band to the position of the original voice band in the frequency spectrum.

2. The method of preventing distortion due to the intermodulation of component signal frequencies arising from the transmission over a transmission circuit of signal frequencies having amplitudes great enough to overload a translating device in the circuit, which consists in modulating the signal band with a carrier having a frequency such as to produce a side band, the upper limiting frequency of which is less than the second harmonic of its lower limiting frequency, selecting from the components resulting from modulation such side band only, transmitting the band thus selected, limiting the energy so transmitted to an amount less than the peak value of the band, thereby producing intermodulation between the component frequencies of the band, selecting from the resultant frequencies a band corresponding to the side band originally selected, and detecting the selected band to produce a band of frequencies corresponding to the original voice band, said band having limited energy.

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 elevate the signal band in the frequency spectrum to a

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point such that its upper limiting frequency will be less than the second harmonic of its lower limiting frequency, means to limit the transmission of the energy of the band thus
5 elevated, thereby producing intermodulation components, means to select from the resultant frequencies a band corresponding to the original elevated band, and means to
10 lower the selected band to a position in the frequency spectrum corresponding to the original signal band.

4. In a signaling system, a transmission circuit including translating devices adapted, when overloaded, to produce intermodu-
15 lation 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 over-
20 loading comprising means to modulate the signal band with a carrier so chosen as to produce a side band, the upper limiting frequency of which will be less than the second harmonic of its lower limiting frequency,
25 means to select from the modulated components said side band only, means to limit the transmission of the energy of the selected side band, thereby producing intermodulation components, means to select from the
30 resultant frequencies a band corresponding to the side band originally selected, and means to demodulate the selected band, thereby producing a band of signal frequencies of limited energy corresponding to the
35 original signal band.

5. In a signaling system, a transmission circuit including translating devices adapted, when overloaded, to produce intermodulation components, means to transmit over
40 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 a modulator, means to
45 impress the signal band upon such modulator together with the carrier so chosen as to produce a side band, the upper limiting frequency of which is less than the second harmonic of its lower limiting frequency,
50 said modulator being balanced to suppress the unmodulated carrier component, means to select said side band only, a power limiting device to limit the energy of the side band selected to a predetermined amount
55 whereby intermodulation components result when the energy exceeds said limit, means to select from the resultant frequencies a band corresponding to the side band originally selected, a demodulator, means to impress
60 upon said demodulator the band finally selected together with a carrier frequency corresponding to the carrier frequency impressed upon the modulator, thereby producing a band of limited energy corresponding
65 to the original signal band, and means to select said band.

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

HERMAN A. AFFEL.