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A. J. SORENSEN

2,491,590

MEANS FOR LIMITING THE MODULATION OF THE OUTPUT
OF TRANSMITTERS OF COMMUNICATION SYSTEMS

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3 Sheets-Sheet 1

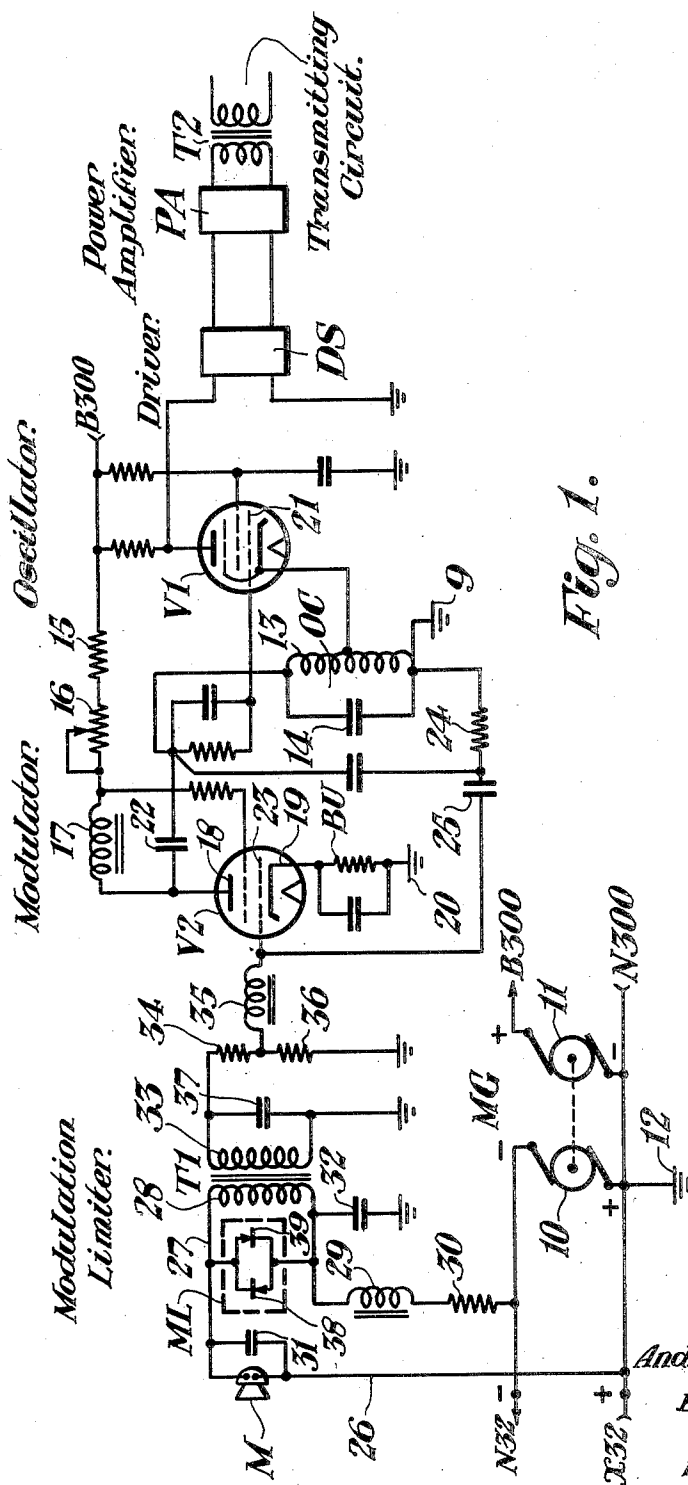


Fig. 1.

INVENTOR.
Andrew J. Sorensen
BY *[Signature]*
HIS ATTORNEY

Dec. 20, 1949

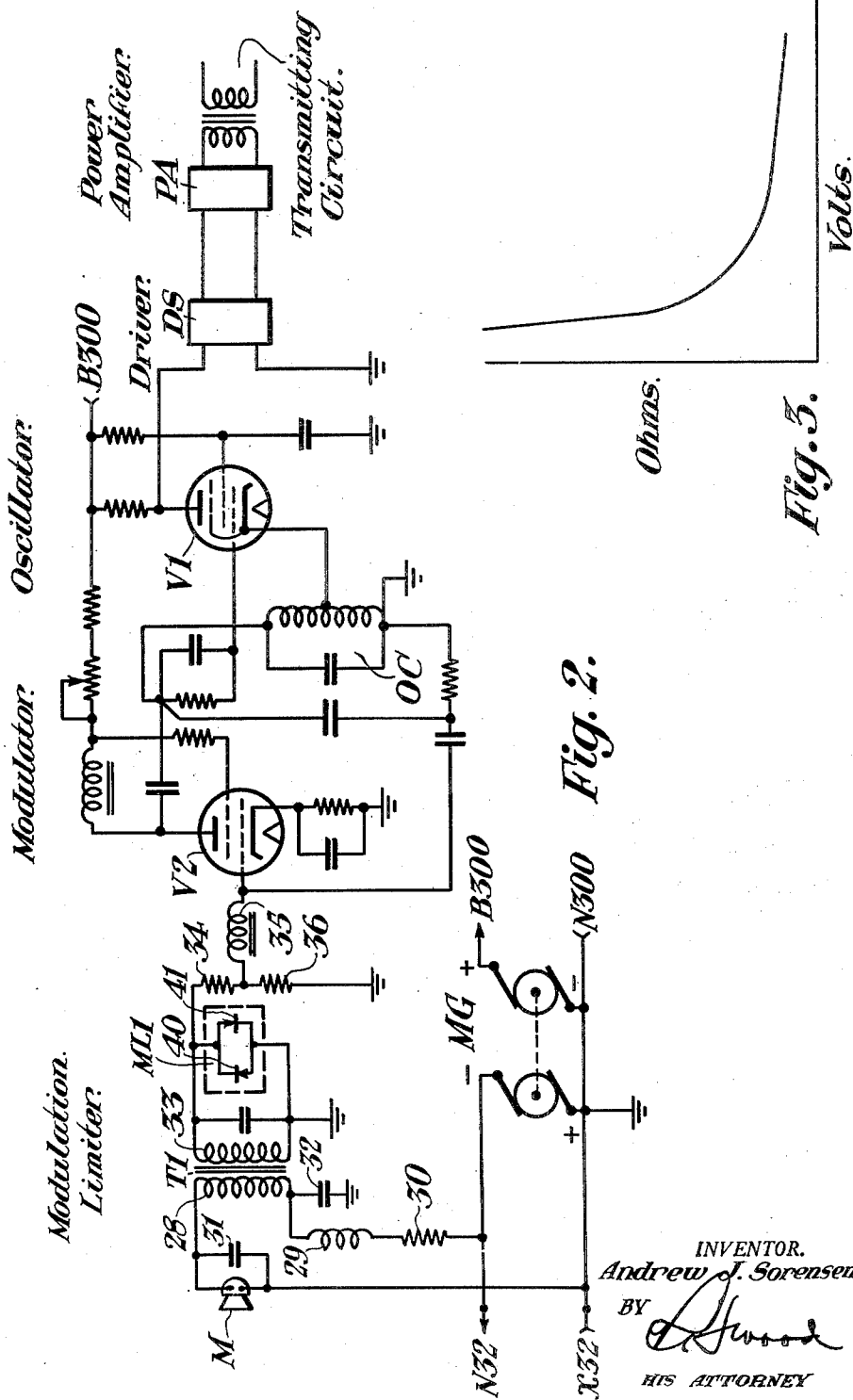
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3 Sheets-Sheet 3

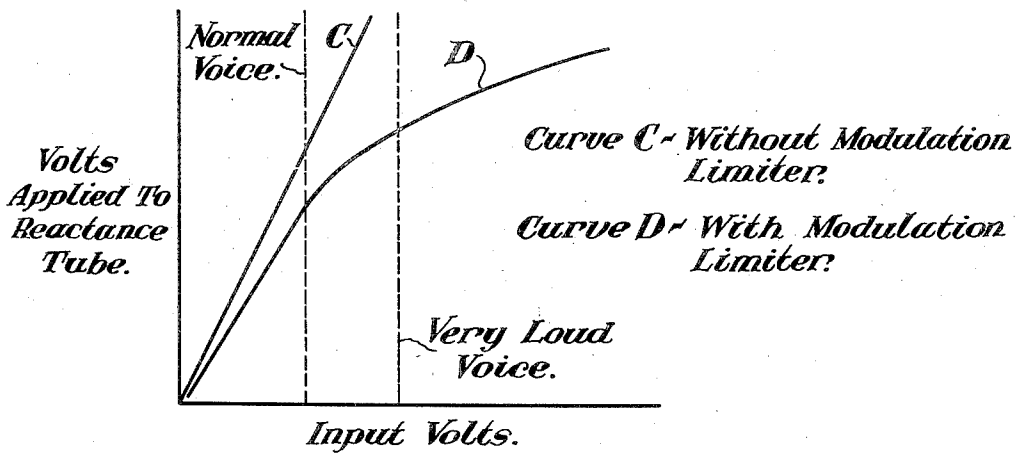


Fig. 4.

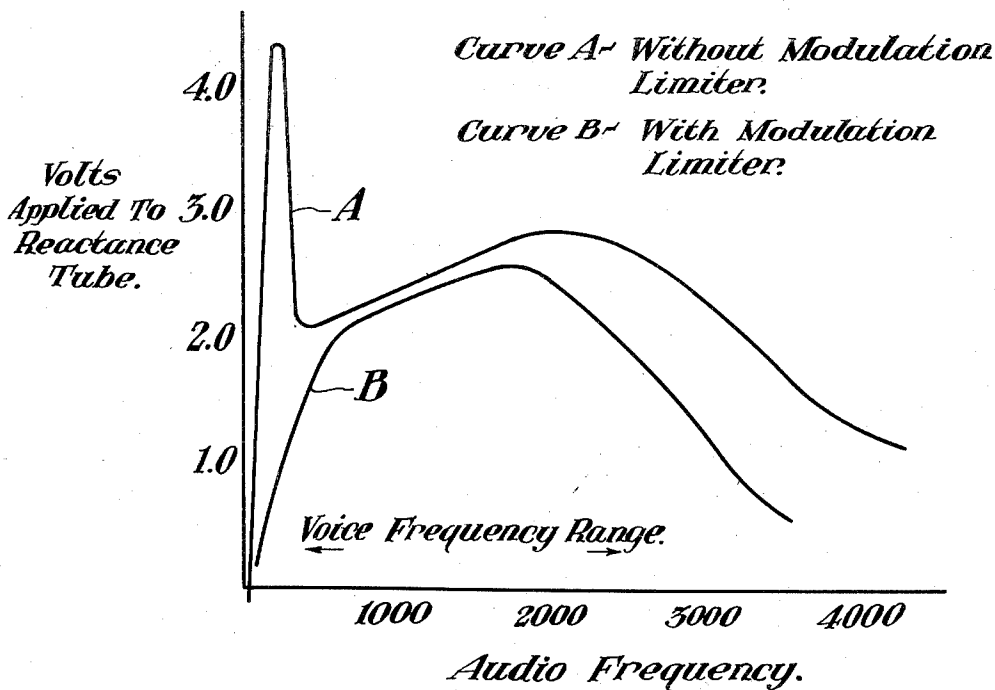


Fig. 5.

INVENTOR.
Andrew J. Sorensen.
BY 
HIS ATTORNEY

UNITED STATES PATENT OFFICE

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MEANS FOR LIMITING THE MODULATION
OF THE OUTPUT OF TRANSMITTERS OF
COMMUNICATION SYSTEMS

Andrew J. Sorensen, Edgewood, Pa., assignor to
The Union Switch & Signal Company, Swiss-
vale, Pa., a corporation of Pennsylvania

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5 Claims. (Cl. 332—19)

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My invention relates to means for limiting the modulation of the output of transmitters of communication systems, and more particularly to means for limiting the modulation of the output of transmitters of carrier telephone systems.

The transmitters of many communication systems must function under widely different conditions. For example, in railway train carrier telephone systems the transmitter must at times operate on a locomotive where high background noise prevails and extreme bursts of noise occur. Also at such locations there is a tendency for the operator to speak in a loud voice and close to the microphone when telephoning. At other locations, such as a wayside office, the ambient noise may be relatively low and the operator may often be some distance away from the microphone and there may be a tendency for him to speak in a low voice.

Furthermore, the circuit network for connecting the microphone to the modulator of the transmitter generally includes capacitance and inductance and the impedance of the circuit network is subject to considerable variation with frequency. This results in resonant conditions occurring at certain frequencies giving a large undesired response at these particular frequencies.

Again, carrier telephone systems of the type here contemplated operate on an assigned frequency channel and it is necessary to prevent the transmitter from producing frequencies extending into the adjacent channel which would otherwise cause undesired response in the system assigned to the adjacent channel.

Accordingly, a feature of my invention is the provision of novel and improved means for limiting the modulation of the output of transmitters of carrier communication systems.

Another feature of my invention is the provision of novel and improved means to secure a more nearly uniform output of a transmitter of a carrier telephone system for loud and low voices.

Again, a feature of my invention is the provision of improved means to reduce the effects of high noise level and violent bursts of noise on transmitters of carrier telephone systems.

Still another feature of my invention is the provision of a carrier telephone system transmitter incorporating improved means to minimize the effects of resonance in the microphone circuit network.

A more specific feature of my invention is the provision of improved means for limiting the

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modulation of the carrier of a railway train inductive carrier telephone system using frequency modulation, and thereby secure a more nearly uniform frequency deviation of the carrier from its designated center frequency for loud and low voices.

Other features, objects and advantages of my invention will appear as the specification progresses.

The foregoing features, objects and advantages of my invention I attain by providing a transmitter incorporating a modulation limiter in a circuit network connecting the microphone to the modulator. This circuit network includes a microphone transformer and its usual capacitance and inductance and the modulation limiter, the limiter being interposed in the network in either the primary or the secondary side of the microphone transformer. The modulation limiter comprises two asymmetric units connected in parallel opposition. These asymmetric units are characterized by a forward direction resistance that is a function of the applied voltage. That is to say, the resistance of each asymmetric unit decreases as the applied voltage increases. Preferably, the asymmetric units are of a dry surface contact type and may be, for example, a stack of copper oxide rectifier discs or elements. Each asymmetric unit is preselected as to the number of discs it includes so that the stack of discs is proportioned to agree with the voltage of the circuit in which the unit is connected. Also, the rectifier elements are selected as to their size for the limiter to impedance match the primary or secondary winding of the microphone transformer according as the limiter is interposed in the network on the primary or secondary side of the transformer.

By such proportioning, the limiter has almost uniform impedance over the essential part of the voice frequency band, but at the low frequencies, such as, 200 cycles and below, and at frequencies above a given value, such as 3000 cycles, the limiter acts as an effective band pass filter. In this way the modulation limiter secures a more uniform response for loud and low voices, and extremely loud voices will not overload the transmitter to the extent that would be possible without the limiter.

Under very noisy conditions, the effects of the high noise level will be considerably minimized because the noise which always fills in the gaps in the conversation will be materially reduced. Also, violent bursts of noise will not be able to

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operate the modulator off its usual range of operation and interference and distortion due to over modulation will be reduced. Furthermore, the tendency toward resonance in the microphone circuit network will be either suppressed or greatly minimized.

I shall describe two forms of means for limiting the modulation of the output of transmitters embodying my invention and shall then point out the novel features thereof in claims.

In the accompanying drawings, Figs. 1 and 2 are diagrammatic views showing a first and a second form, respectively, of a transmitter incorporating modulation limiting means embodying my invention, the transmitter being that for a carrier telephone system using frequency modulation. Figs. 3, 4, and 5 are diagrams showing different characteristics of the modulation limiting means of Figs. 1 and 2.

In each of the several views like reference characters are used to designate similar parts.

It is to be understood that the invention is not confined to a transmitter using frequency modulation and this one application illustrates the many places the apparatus is useful.

Referring to Fig. 1, the transmitter includes a microphone, a modulation limiter, a modulator, an oscillator, and a power source as the essential elements.

The power source may be any convenient arrangement and as here disclosed it includes a low voltage source and a motor generator for converting a low voltage into a voltage suitable for energizing the anode circuits of the electron tubes of the transmitter. The low voltage source may be a 32 volt battery, not shown, the terminals of which are indicated at X32 and N32. A motor generator MG has its motor 10 connected across the terminals X32 and N32 for operation thereof. The generator 11 of the motor generator supplies a relatively high direct voltage, such as 300 volts, the terminals of the generator being indicated as B300 and N300. Following the usual custom, the positive terminal X32 of the low voltage source and the negative terminal N300 of the generator are connected to a ground electrode 12.

The oscillator is preferably of the electron tube type, and as here disclosed it includes an oscillating circuit OC and an electron tube V1. The oscillating circuit OC is of a standard form of a parallel connected inductance 13 and capacitance 14. The tube V1 is a pentode but other tubes can be used. The anode-cathode circuit of tube V1 is powered from generator 11 and the oscillating circuit OC is connected to the tube in a well-known arrangement as will be apparent by an inspection of Fig. 1. The parts are so proportioned that oscillations of a definite carrier frequency are produced, and as an aid in understanding the invention I shall assume that the oscillator supplies a carrier current of 100 kc. but other carrier frequencies can be provided.

The output of this oscillator will be connected to any suitable form of transmitting circuit and in Fig. 1 the oscillator is shown coupled to a transmitting circuit through a driver stage DS and a power amplifier PA, the output of the power amplifier including an output transformer T2. The driver stage DS and power amplifier PA are shown in block form because these devices can be of standard arrangements for such devices and they are not essential elements of the invention. It is apparent that if

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additional amplification of the communication current is not required, the driver stage DS and power amplifier PA may be omitted.

The modulator of the transmitter is of the reactance tube form and includes an electron tube V2, the tube V2 being here shown as a tetrode but other tubes can be employed. The tube V2 is provided with an anode-cathode circuit which extends from terminal B300 of generator 11 through resistors 15 and 16, inductance coil 17, anode 18 and tube space to cathode 19 of tube V2, a biasing unit BU and ground electrodes 20 and 12 to negative terminal N300 of the generator. This anode-cathode circuit is coupled to the oscillating circuit of the oscillator, the anode of tube V2 being connected to one terminal of the circuit OC through a coupling capacitor 22 and the cathode side of the anode-cathode circuit being connected to the other terminal of the oscillating circuit through ground electrodes 20 and 9. Also the circuit OC is connected to control grid 23 of tube V2 through resistor 24 and capacitor 25. It is apparent that the tube V2 is in parallel with the oscillating circuit and the reactance of the tube V2 will vary the oscillating circuit and cause corresponding variations of the oscillations supplied by the oscillator. Thus it is seen that voltages applied to control grid 23 of tube V2 to vary the reactance of the tube will serve to frequency modulate the carrier supplied by the oscillator.

A microphone M is connected to the input of the modulator tube V2 through a circuit network including a transformer T1 and a modulation limiter ML. Specifically the microphone M is provided with a circuit that can be traced from terminal X32 of the low voltage source through wire 26, microphone M, wire 27, primary winding 28 of transformer T1, inductance coil 29 and resistor 30 to terminal N32 of the current source, a capacitor 31 being connected across the microphone and a capacitor 32 being connected between the terminal of primary winding 28 remote from the microphone, and ground. A secondary winding 33 of the microphone transformer T1 is tuned by a capacitor 37 and it has one terminal connected to control grid 23 of the modulator tube V2 through a resistor 34 and an inductance coil 35 and its other terminal connected to ground, a resistor 36 being connected between the junction terminal of resistor 34 and coil 35 and ground. It follows that audio frequencies impressed upon the microphone M cause corresponding variations in the current flowing in the microphone circuit and these current variations induce a corresponding electromotive force in secondary winding 33 of the transformer, and this electromotive force is impressed upon the control grid 23 of the modulator tube V2 to vary the reactance of the tube and frequency modulate the carrier supplied by the oscillator. That is, noise energy impressed upon the microphone and an operator speaking into the microphone cause corresponding frequency modulation of the carrier.

As is well known in frequency modulation systems, the amplitude of the modulating energy determines the frequency deviation of the carrier from its designated center frequency. Thus, with a given assigned frequency band of say, for example, plus or minus 3 kc., for the transmitter here involved, a voltage of a magnitude greater than a given value applied to the modulator tube V2 will over-modulate the carrier and cause a

frequency deviation beyond the assigned band.

The modulation limiter ML comprises two asymmetric units 38 and 39 connected in parallel opposition. In Fig. 1 the limiter ML is connected across the primary winding 28 of the microphone transformer T1. The asymmetric units 38 and 39 are alike and are preferably of the dry contact surface type, such as for example, the well-known copper oxide rectifier element. These asymmetric units are characterized by a resistance in their forward direction that is a function of the voltage applied. This characteristic feature is illustrated by the curve in Fig. 3, the resistance of the unit decreasing rapidly with an increase in the voltage applied thereto for a given range of voltages. The units 38 and 39 are made up of a stack of rectifier elements, the number of elements used in the stack being determined by the voltage appearing across the primary winding 28 of the microphone transformer. In practicing the invention I have found that the voltage appearing across the primary winding of the microphone transformer is relatively low and a stack of copper oxide rectifier elements of six discs is usually satisfactory. The size of the rectifier elements or discs is selected so that the limiter ML impedance matches the primary winding of the transformer.

Due to the capacitance and inductance involved in this microphone circuit network, the network approaches resonance at certain audio frequencies and undesired responses are effected at such frequencies. I have found that for a microphone circuit network of a transmitter that is in commercial use, the voltage applied to the reactance tube of the transmitter varies substantially according to a curve A of Fig. 5 for audio frequencies when the modulation limiter ML is not used. It is to be noted from curve A that at a low audio frequency of the order of 200 cycles per second a resonant condition occurs and a very high voltage is applied to the reactance tube. This means that voice frequencies and noise energy frequencies of the order of 200 cycles create a response in the oscillator that is all out of proportion to the importance of these frequencies. Again, as shown by curve A, a resonant condition is approached and a high value of voltage applied to the reactance tube for frequencies over 2500 cycles. In other words, there is an undesired response to voice and noise energy frequencies of the order of 2500 cycles. Thus with transmitters as heretofore used an undesired response is effected to very low frequencies and also at the upper limit of the voice frequency band desired, the usual voice frequency band being taken as extending from 400 to 2500 cycles in systems of the type here involved.

With the modulator limiter ML connected into the circuit network, the voltage appearing at the modulator tube for different audio frequencies is substantially that illustrated by the curve B of Fig. 5. It is to be observed from curve B that with the modulator limiter the high voltage peak of the low audio frequency of 200 cycles is entirely suppressed and the high response of the higher audio frequency of the order of 2000 to 2500 cycles is greatly reduced. In fact the curve B shows that the response for energy between 400 and 2500 cycles is substantially uniform, or at least it is much more nearly uniform than that obtained without the use of the modulation limiter.

Again, in Fig. 4, the curve C shows the variations of the voltage applied to the modulator tube

for different values or amplitudes of the input voltage, that is, the voltage created in the microphone circuit by speaking into the microphone when the modulator limiter ML is not used. The curve D shows this operating characteristic of the microphone circuit network when the modulator limiter ML is used. It is to be noted from curves C and D that the voltages applied to the modulator tube increase much less between a normal voice and a very loud voice when the modulation limiter is used. That is, the response of a transmitter is much more nearly uniform between loud and low voices when the modulator limiter is connected into the microphone circuit network. In other words, over-modulation is reduced by use of the modulation limiter.

Referring to Fig. 1, it is also to be noted that a blocking capacitor may be connected in series with the modulation limiter ML to block the flow of direct current of the microphone circuit through the limiter, but I have found that under the usual condition the direct voltage drop across the primary winding 28 of the microphone transformer is low and a blocking capacitor in series with the modulation limiter is not required.

In Fig. 2, the transmitter is substantially the same as that in Fig. 1 except a modulation limiter ML1 is connected across the secondary winding 33 of the microphone transformer T1 in place of the limiter being connected across the primary winding as shown in Fig. 1. The limiter ML1 is composed of two asymmetric units 40 and 41 connected in parallel opposition the same as the asymmetric units of the limiter ML of Fig. 1. Ordinarily, the voltage across the secondary winding of the microphone transmitter is higher than the voltage across the primary winding and thus the units 40 and 41 of the limiter ML1 are made up of a greater number of rectifier discs to agree with this higher voltage of the secondary winding. Also, the discs are of a smaller size for the limiter ML1 to impedance match the secondary winding 33 of the microphone transformer. When thus constructed the modulator limiter ML1 provides the transmitter of Fig. 2 with operating characteristics substantially the same as those obtained for the transmitter of Fig. 1 by the modulation limiter ML.

In practicing the invention, I have found that transmitting apparatus here disclosed when used with a railway train inductive carrier telephone system not only has the advantages of assuring a nearly uniform response for loud and low voices but also the effects of background noise and bursts of noise are minimized giving a higher order of intelligibility of the transmitted speech. Also, over-swinging or over-modulation of the carrier frequency beyond the assigned band is avoided. Furthermore, by proper choice of the modulation limiter, the transmitter is an unexpected improvement due to the suppression of the resonant conditions that ordinarily occur in the microphone network when the modulation limiter is not used.

Although I have herein shown and described but two forms of means for limiting the modulation of the output of transmitters of communication systems embodying my invention, it is understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of my invention.

Having thus described my invention, what I claim is:

1. In a transmitter for a carrier telephone

system, the combination comprising, an electron tube modulator having connections to a source of carrier current of a definite frequency for modulating the carrier current according to voltage variations applied to a control electrode of the modulator tube, a microphone, a transformer, a first circuit means including capacitance and inductance to connect said microphone to a primary winding of said transformer, a second circuit means including capacitance and inductance to connect a secondary winding of said transformer to said control electrode and a cathode of said tube, a modulation limiter comprising a pair of asymmetric units connected in parallel opposition, said asymmetric units characterized by an impedance that is a function of the voltage applied thereto, said modulation limiter connected across said primary winding of said transformer to limit the magnitude of the voltages appearing across said primary winding for limiting the magnitude of the voltages applied to said modulator tube.

2. In a transmitter for a carrier telephone system, the combination comprising, an electron tube modulator having connections to a source of carrier current of a definite frequency for modulating the carrier current according to voltage variations applied to a control electrode of the modulator tube, a microphone, a transformer, a first circuit means including capacitance and inductance to connect said microphone to a primary winding of said transformer, a second circuit means including capacitance and inductance to connect a secondary winding of said transformer to said control electrode and a cathode of said tube, a modulation limiter comprising a pair of asymmetric units connected in parallel opposition, said limiter connected across said primary winding, and said asymmetric units having a forward direction characteristic of a decreasing impedance with an increase of applied voltage and proportioned to impedance match said primary winding to modify the voltage applied to said tube due to loud speaking into said microphone and to resonant conditions of said first circuit means.

3. In a transmitter for a carrier telephone system using frequency modulation, the combination comprising, an electron tube oscillator for supplying a carrier of a definite center frequency, a reactance modulator tube connected to said oscillator to frequency modulate said carrier according to voltages applied to a control electrode of said modulator tube, a microphone, a transformer, a first circuit means including a source of current to connect said microphone across a primary winding of said transformer, a second circuit means to connect a secondary winding of said transformer to said control electrode of said modulator tube to apply to said control electrode voltages created by audio frequencies impressed on said microphone, a modulation limiter comprising two asymmetric units arranged in parallel opposition, said units characterized by an impedance which varies with the voltage applied thereto, and said limiter connected across said first circuit means and proportioned to limit the voltage applied to said primary winding and to eliminate resonant conditions of the first circuit means at voice frequencies to confine the frequency deviation of said carrier to a given value each side of the center frequency.

4. In a transmitter for a carrier telephone sys-

tem using frequency modulation, the combination comprising an electron tube oscillator for supplying a carrier of a definite center frequency, a reactance modulator tube connected to said oscillator to frequency modulate said carrier according to voltages applied to a control electrode of said modulator tube, a microphone, a transformer, a first circuit means including a source of current to connect said microphone across a primary winding of said transformer, a second circuit means to connect a secondary winding of said transformer to said control electrode of said modulator tube to apply to said control electrode voltages created by audio frequencies impressed on said microphone, a modulation limiter comprising two asymmetric units arranged in parallel opposition, said units characterized by an impedance which varies with the voltage applied thereto, and said limiter connected across said second circuit means and proportioned to govern the voltage applied to said modulator tube to a given magnitude.

5. In a transmitter for a carrier telephone system using frequency modulation, the combination comprising; an oscillator including an electron tube having an anode, a cathode and a control electrode and an oscillating circuit having capacitance and inductance; said oscillator made operable to supply a carrier of a definite center frequency; a reactance modulator tube having an anode, a cathode and a control electrode; said modulator tube having an anode-cathode circuit coupled across said oscillating circuit to frequency modulate said carrier according to voltage variations applied to said control electrode and cathode of said modulator tube, a microphone, a transformer, circuit means including a source of current to connect said microphone across a winding of said transformer, another circuit means to couple another winding of said transformer to said control electrode and cathode of said modulator tube to apply to the control electrode voltages created by audio frequencies impressed on said microphone, a modulation limiter comprising two electrical asymmetric units of the dry surface contact type arranged in parallel opposition, said modulation limiter connected across a selected one of said transformer windings to control the voltages applied to the control electrode of the reactance modulator tube, said asymmetric units having a forward direction characteristic of a rapidly decreasing impedance for a given range of applied voltages to limit the voltages applied to the modulator tube due to loud speaking into the microphone, and said asymmetric units selected as to their size for their elements to have a given impedance to impedance match the winding to which the limiter is connected to minimize resonant condition effects of said first mentioned circuit means.

ANDREW J. SORENSEN.

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