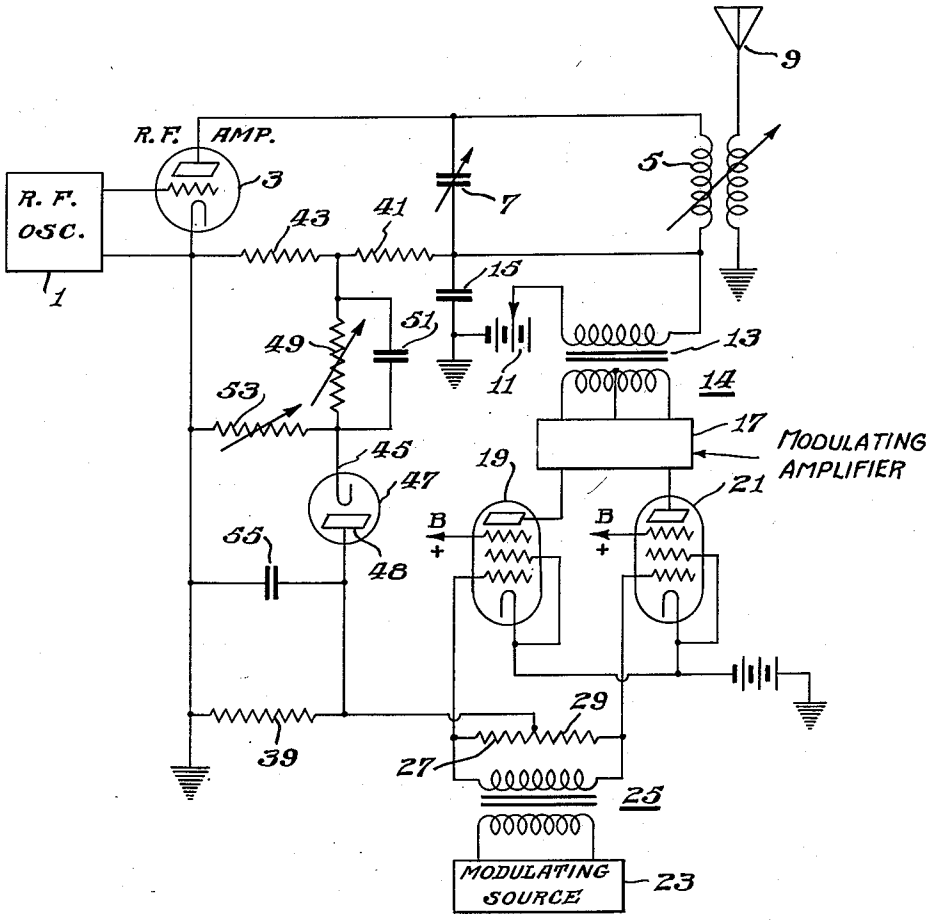
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MODULATION LIMITER

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INVENTORS:
Harold J. Schrader,
John M. Brumbaugh,
& Ben W. Robins

By

Attorney

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MODULATION LIMITER

Harold J. Schrader, Haddon Heights, and Ben W. Robins, Haddonfield, N. J., and John M. Brumbaugh, Lansdowne, Pa., assignors to Radio Corporation of America, a corporation of Delaware

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This invention relates to modulation systems, and more particularly to a method of and means for providing a modulation limiter which automatically prevents excessive modulation, reduces distortion, and makes possible the automatic maintenance of nearly constant percent modulation for a wide range of modulating signal level.

Modulated transmitters are usually provided with a manual control means for reducing the amplitude of the modulating voltage when it tends to increase beyond a predetermined level. While this manual control system has certain advantages, it is frequently desirable to provide a system which requires no attention and which operates automatically not only to prevent excessive modulation but also to maintain the percent modulation at a substantially constant level notwithstanding fluctuations in the amplitude of the modulating voltage and in the normal transmitter output. The mere provision of an automatic volume control in the audio amplifier of a modulated transmitter does not provide a satisfactory answer to the problem, since normal variations in the sound intensity are thereby reduced, tending to prevent the faithful reproduction of the transmitted intelligence. A biased automatic volume control system in the audio system will prevent overmodulation on occasional peaks, but can not maintain the modulation level at a constant value.

It is frequently desirable to vary the power output of a transmitter. One convenient way of accomplishing this is to vary the plate voltage which is applied to the high power radio frequency amplifiers. In transmitters which utilize "high level" modulation, that is, modulation which is accomplished by superimposing a modulated alternating voltage on the direct plate voltage which is applied to the output tubes it is evident that such a variation of the output power necessitates a readjustment of the amplitude of the modulating voltage, if the percent modulation is to be held at the original level. So also, if a limiting system is used which tends to limit the amplitude of the modulating voltage to prevent overmodulation, the point at which the limiting action is instituted must also be varied when the output of the transmitter is varied. This requires constant attention on the part of an operator, and is therefore objectionable. It is the primary object of this invention, therefore, to provide a modulation system which automatically maintains the percent modulation at a desired value, or prevents its increase beyond a desired value, independent of changes in the transmitter output.

In addition to changing the direct voltage which is applied to the output amplifier for the purpose of readjusting the transmitter output, as described above, undesired variations of the direct voltage source frequently produce uncontrollable changes in the amplifier plate voltage. This is particularly true in portable transmitters which are battery operated, or where the transmitter is transferred to an emergency power supply system. Since the percent modulation is a function of the ratio of the direct plate voltage, which is approximately equal to the average unmodulated carrier voltage on the plate, and the superimposed modulating voltage, if limiting is to be accomplished at a predetermined percent modulation without continual readjustment to compensate for desired or undesired changes in the plate voltage, the point at which the limiting action is instituted must vary in proportion to the amplitude of the plate voltage. It is, therefore, a further object of this invention to provide a limiting system in which the point of operation is proportional to the plate voltage which is applied to the modulated amplifier.

This invention will be better understood from the following description when considered in connection with the accompanying drawing. The figure of the drawing is a schematic diagram of a preferred embodiment of this invention.

Referring to the drawing, 1 is a radio frequency oscillator of any desired characteristic which is coupled to the input of a radio frequency amplifier 3. The output circuit of amplifier 3 includes an inductor 5 and capacitor 7, the former of which is coupled to an antenna 9. The plate voltage which is applied to the amplifier 3 is derived from a suitable source such as a battery 11 which is connected in series with the secondary 13 of a modulating transformer 14 between ground and the low potential end of inductor 5. A radio frequency by-pass capacitor 15 is connected across battery 11 and secondary 13. A modulating voltage is induced in the secondary of the modulating transformer by means of a modulating amplifier 17, which is in turn energized by a pair of remote cut-off audio frequency amplifier tubes 19 and 21.

A source of modulating voltage 23 is coupled to the grids of the remote cut-off tubes 19 and 21 by any suitable means, such as a transformer

25. A pair of isolating resistors 27 and 29 are connected between the respective grids of the remote cut-off tubes and one terminal of a biasing resistor 39, the other terminal of which is connected to ground. The system so far described is a "high level" modulated amplifier, the operation of which is well known to those skilled in the art. The limiting circuit will now be described.

A voltage divider comprising resistors 41 and 43 is connected between ground and the high potential terminal of the secondary winding 13. The junction of resistors 41, 43 is connected to the cathode 45 of a diode rectifier 47 through a parallel circuit comprising a variable resistor 49 and a capacitor 51. Cathode 45 is also connected to ground through a variable resistor 53. The anode 48 of diode 47 is connected to the ungrounded terminal of biasing resistor 39, and also to ground through a bypass capacitor 55.

The radio frequency amplifier plate voltage is determined by two components, a direct voltage which is produced by the battery 11, and an audio frequency voltage which is developed across the secondary 13 of the modulation transformer. The modulating voltage is added to the battery voltage during positive peaks of the modulating voltage, and is subtracted from the battery voltage during negative peaks of the modulating voltage. One hundred percent modulation of the radio frequency carrier is therefore accomplished when the amplitude and polarity of the modulating voltage is such that the effective plate voltage on the amplifier tube 3 is reduced to zero. If the modulating voltage exceeds this value deleterious distortion is produced, since the radio frequency output cannot be reduced beyond the zero point. The envelope of the modulated carrier wave, therefore, does not truly represent the wave shape of the modulating voltage.

To prevent this distortion, the amplitude of the modulating voltage must be maintained at a value which is less than the value which reduces the plate voltage to zero. Consequently, variations in the potential of battery 11 necessitates the readjustment of the maximum amplitude of the modulating voltage if overmodulation is to be avoided. At the same time, it is to be remembered that it is always desirable to operate the transmitter at the highest average percent modulation possible, in order to fully utilize the available radio frequency energy.

In accordance with this invention, a bias voltage is developed by rectifier 47 when the modulating voltage exceeds a predetermined proportion of the direct plate voltage, which, as noted above, is equivalent to the average unmodulated carrier voltage. It will be seen that the cathode 45 of diode 47 is impressed with a direct voltage and an alternating voltage. The amplitude of the direct voltage is determined by the attenuation produced in the voltage divider comprising resistors 41 and 43, and the further attenuation which is provided by resistors 49 and 53. A positive D. C. bias is, therefore, applied to cathode 45, the amplitude of which is proportional to the amplitude of the direct voltage which is applied to the amplifier plate. By adjusting either or both of resistors 49 and 53, the amplitude of the biasing voltage may be set to any desired value.

The amplitude of the alternating component is likewise affected by two attenuators. Resistors 41 and 43 provide a like attenuation for both the direct and alternating components. The purpose of this attenuator is merely to reduce the alternating and direct voltages which are applied to the diode 47 to usable values. Capacitor 51, however, bypasses the audio frequency component around resistor 49, so that the full alternating voltage across resistor 43 is applied to the cathode. As a result, the proportion of the direct and alternating voltages which are impressed on rectifier 47 may be independently selected, and thus the point at which rectification commences may be adjusted.

When the alternating component present on cathode 45 exceeds the amplitude of the direct component, diode 47 draws a current through resistor 39, and the anode 48 develops a negative potential. This negative potential is applied as a bias to the grids of the remote cut-off amplifiers 19 and 21. The percent modulation at which the limiting action commences is approximately equal to the attenuation produced by resistors 49 and 53. That is, if the value of resistor 53 is equal to four times the value of resistor 49, then the D. C. component on cathode 45 will be four-fifths of the A. C. component, assuming the two voltages to be of equal amplitude at the midpoint of resistors 41 and 43. The limiting action will, therefore, commence at 80 percent modulation, beyond which the audio amplifiers 19 and 21 receive an increased negative bias to reduce or prevent a further increase in the modulation due to a further increase of voltage at the modulating source 23.

If the output of the transmitter is varied by adjusting the amplitude of the direct voltage produced by battery 11, the direct voltage present on cathode 45 will be likewise altered, so that the limiting action will automatically commence at that value of modulating voltage which produces the desired maximum modulation at the new plate voltage. The same is true, of course, for variations in the direct plate voltage which occur during normal operation due to changes in the battery or line voltage, since in practice the battery 11 would usually be replaced by a rectifier-filter system, as is well known.

A further advantage of the system illustrated arises from the fact that the control bias for the amplifier tubes 19 and 21 is derived from a voltage which is proportional to the actual modulating voltage. Thus, changes in the gain of the modulator 17, or in amplifier tubes 19 and 21, are automatically compensated through the bias voltage developed in the limiting system.

The system illustrated may be operated so as to prevent overmodulation due to occasional peaks by keeping the audio frequency voltage at an average value which is well below that necessary to produce maximum modulation, or if desired the modulation voltage may be increased to a value at which the limiting action is in operation a large portion of the time. In the former case, the original dynamic sound range is maintained, but in the latter case the dynamic range is reduced.

We have thus described an improved system for limiting voltage impulses which would tend to overmodulate a transmitter, and which may also maintain the average modulation at a selected value. The invention is not to be limited to the specific apparatus illustrated since various modifications will occur to those skilled in the art. The audio amplifier tubes 19 and 21 may be triodes, if desired, nor is it necessary to use a push-pull amplifier as shown. It is apparent that

other modulating system may be employed, such as the well known grid modulating system.

We claim as our invention:

1. In a modulation limiter, a radio frequency amplifier, means including a modulation frequency amplifier for applying a modulated direct voltage to said radio frequency amplifier, and control means operable in response to a modulation frequency voltage whose amplitude exceeds a predetermined percentage of the applied direct component for deriving a control voltage, means for utilizing said control voltage to limit the gain of said modulation frequency amplifier, said control means including a unilateral discharge device normally biased to cut-off solely by a direct voltage proportional to said direct component.

2. In a device of the character described, a thermionic discharge device, a source of direct plate voltage for said device, modulating means including a modulation frequency amplifier for applying a modulating voltage to the plate of said device, a unilateral discharge device, impedance means in circuit with said unilateral discharge device for applying a control bias to said modulation frequency amplifier, said bias being proportional to the current through said unilateral discharge device, separate means for applying to said unilateral discharge device relatively adjustable direct and alternating voltages proportional to said direct plate voltage and said modulating voltage, respectively, said means comprising a resistive voltage divider across a portion of which a capacitor is connected, the polarities of said voltages being such that said unilateral discharge device becomes conductive only when the amplitude of said modulating voltage exceeds a predetermined proportion of the direct plate voltage of said amplifier tube.

3. In a modulation limiter, a radio frequency amplifier, means including a modulation frequency amplifer for applying a modulated direct voltage to said radio frequency amplifier, a unilateral discharge device having cathode and anode electrodes, means for applying to said device a controllable biasing potential proportional to a desired fraction of the direct component applied to said radio frequency amplifier, said means being the sole biasing means for said device, means for also applying to said device an alternating voltage proportional to the modulation frequency component of said applied voltage to thereby develop a control voltage whenever said modulation frequency component exceeds said controllable biasing potential, and means for applying said control voltage to said modulation frequency amplifier to reduce the gain of said amplifier.

4. In a modulation responsive device for a high frequency amplifier having a cathode electrode and another electrode between which unidirectional operating voltage and modulating signal voltage are supplied, said operating voltage being subject to variations and the total voltage between said electrodes being subject to undesired reversal upon high peaks of said signal voltage, a voltage divider for unidirectional voltage connected between said electrodes, a unilaterally conducting device connected across a portion of said voltage divider and poled to be rendered non-conductive by the unidirectional potential thereon, and means for short circuiting at least a portion of the rest of said voltage divider for signal currents so that said device is normally non-conductive but becomes conductive whenever said signal voltage exceeds a predetermined constant fraction of said operating voltage irrespective of the magnitude thereof.

5. In a modulation limiter for a high frequency amplifier having a cathode electrode and another electrode between which unidirectional operating voltage and modulating signal voltage are supplied, said operating voltage being subject to variations, a voltage divider connected between said electrodes, a unilaterally conducting device connected across a portion of said voltage divider adjacent said cathode electrode and poled to be rendered non-conductive by the unidirectional potential thereon, means to short circuit at least a portion of the rest of said voltage divider for signal current whereby a greater portion of said signal voltage is applied to said unilaterally conductive device than of said unidirectional voltage and said device becomes conductive when the ratio between such portions exceeds a predetermined value unchanged by variations of said operating potential, and current responsive means operated by current in said device for reducing said signal voltage.

6. In a modulation limiter for a high frequency amplifier having a cathode electrode and another electrode between which unidirectional operating voltage and modulating signal voltage are supplied, said operating voltage being subject to variations, a unilaterally conducting device, electrically passive means for impressing a bias voltage upon said device with such polarity as to render said device non-conductive, said bias voltage being derived entirely from said operating voltage between said electrodes, means to supply signal voltage to said device to render said device conductive when peaks of said signal voltage exceed said operating voltage applied thereto, the ratio of the signal voltage to the operating voltage supplied to said device being greater than the ratio of signal voltage to operating voltage between said electrodes, whereby said device becomes conductive whenever said signal voltage exceeds a predetermined fraction of said operating voltage between said electrodes irrespective of the magnitude of said operating voltage, and means responsive to current in said unilaterally conducting device to reduce said signal voltage.

7. In a modulation responsive device for a high frequency amplifier having a cathode electrode and another electrode between which unidirectional operating voltage and modulating signal voltage are supplied, said operating voltage being subject to variations and the total voltage between said electrodes being subject to undesired reversal upon high peaks of said signal voltage, a unilaterally conducting device, electrically passive means for impressing a bias voltage derived entirely from said operating voltage upon said device with such polarity as to render said device nonconductive so long as peaks of said signal voltage do not exceed said operating voltage, and means including said first means for supplying said voltages to said device with such relative intensities that said device is normally nonconductive but becomes conductive whenever said signal voltage exceeds a predetermined constant fraction less than unity of said operating voltage between said electrodes irrespective of the magnitude thereof.

HAROLD J. SCHRADER.
BEN W. ROBINS.
JOHN M. BRUMBAUGH.