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AUTOMATIC MODULATION CONTROL CIRCUIT

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FIG. 1

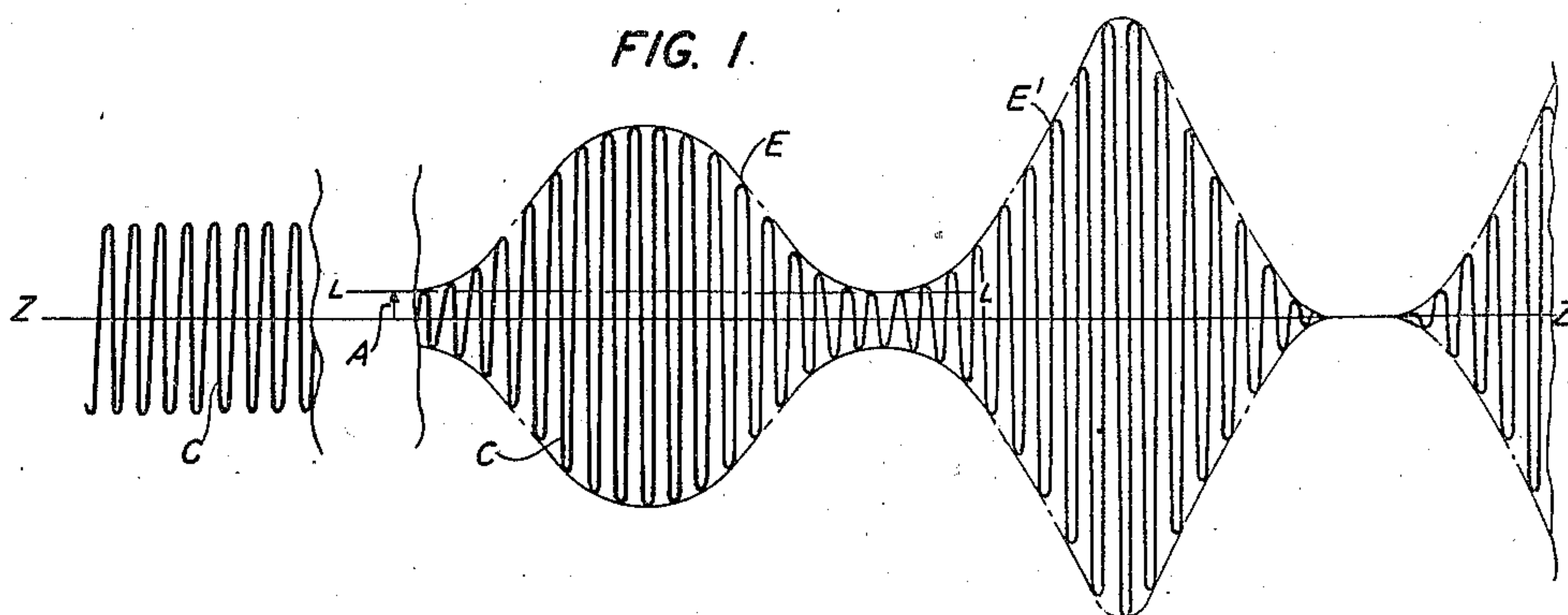
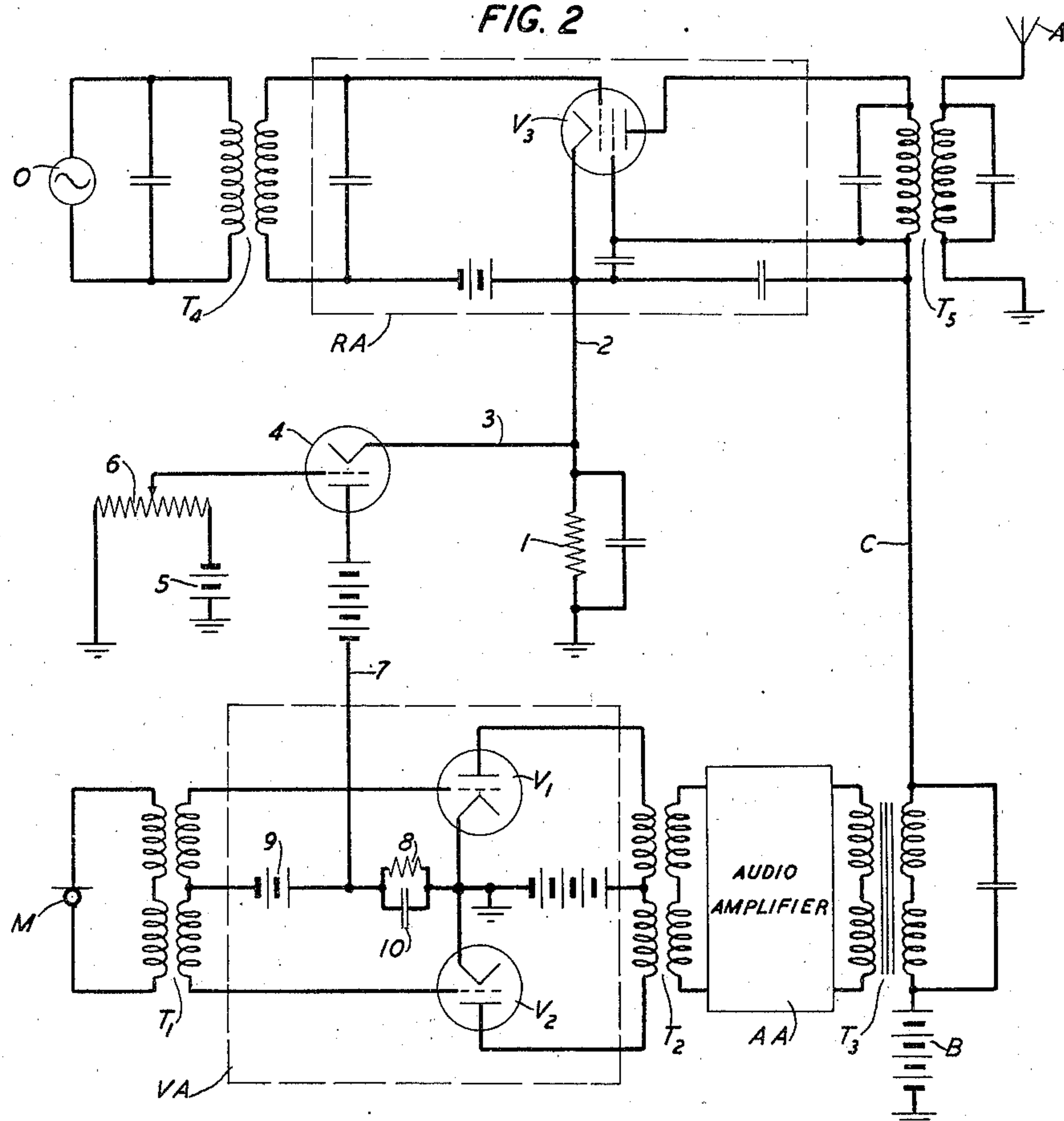


FIG. 2



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AUTOMATIC MODULATION CONTROL
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10 Claims. (Cl. 179—171.5)

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This invention relates to modulation control means and, more particularly, to automatic modulation control means for amplitude modulated radio transmitters.

Heretofore, radio transmitters have employed means for governing the modulating process in a manner such as to prevent the maximum amplitude of a modulated carrier wave from exceeding a predetermined value. Such means as these will prevent excessive modulation of the carrier wave in only a positive direction and will not prevent excessive modulation in a negative direction. In other words, they will not prevent the envelope of a modulated carrier wave from arriving at a zero value. Radio transmitters have also used means to regulate the amplification of modulating signals in an attempt to permit the amplitude of the modulating signals to vary without adversely affecting the peak percentage of modulation. However, these regulating means do not compensate for fluctuations in the amplitude of the carrier wave which might arise from shifts in the frequency of the carrier wave or other causes.

Accordingly, an object of this invention is to govern the modulating process so that the envelope of a modulated carrier wave will not reach a zero value.

Another object of the invention is to regulate the amplitude of modulating signals in such a manner that either the signal amplitude or the carrier amplitude can vary without adversely affecting the peak percentage of modulation.

Still another object of the invention is to regulate the amplitude of modulating signals solely in accordance with the proximity of the envelope of a modulated carrier wave to its zero reference line.

These and other objects of the invention are attained by means of a modulation control utilizing a voltage derived from a resistor connected in the plate circuit of a class-B radio frequency amplifier between the cathode and ground. This voltage, which is representative of the envelope of the modulated carrier wave, is applied to the cathode of a control triode raising the potential of the latter to a positive value. A negative bias voltage is applied between the grid of the control triode and ground and is adjusted to a value that will bias the tube beyond cut-off when the carrier wave is not modulated. When the value of the voltage derived from the cathode resistor becomes small due to the envelope of the modulated carrier wave approaching its zero reference line, the grid of the control triode will, in effect, be made more positive in respect to the cathode. The fixed bias is so chosen that, as the derived voltage falls to a small value, the control triode becomes conductive. Upon becoming conductive, the control triode draws current through a sec-

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ond resistor which is connected to the control grids of the audio amplifier. This increases the negative bias on the control grids thereby reducing the gain of the audio amplifier and consequently preventing overmodulation of the carrier wave in a negative direction.

These and other features of the invention are more fully described in connection with the following detailed description of the drawing in which:

Fig. 1 illustrates the manner in which the envelope of a carrier wave is varied by modulation in accordance with signals; and

Fig. 2 represents a radio transmitting station employing a preferred embodiment of the invention.

The nature of the invention can be better understood from an examination of Fig. 1 which shows a carrier wave C of constant frequency oscillating about its zero reference line Z—Z. The portion of the carrier wave C that is shown at the left in Fig. 1 represents the unmodulated condition during which the amplitude of the carrier is constant. The middle portion of Fig. 1 illustrates the appearance of the carrier modulated with a sine wave signal so that its amplitude now varies over a range extending to nearly twice its unmodulated value. This corresponds to modulation of slightly less than 100 per cent; the envelope of the carrier falling to a value close to zero. The right portion of Fig. 1 shows the appearance of the carrier modulated more than 100 per cent. It can be seen in this portion of Fig. 1 that not only is the peak amplitude of the envelope E' greater than twice the amplitude of the unmodulated carrier, but also there is an appreciable period during which the carrier is so overmodulated in a negative direction that it is completely cut off. Such overmodulation of the carrier is objectionable as it produces distortion of the output of the radio transmitter.

Since the audible output at the receiver in an amplitude modulation system is dependent upon the depth of modulation in the carrier, the optimum transmitting condition would be one in which the maximum modulation of the carrier is limited to 100 per cent. However, as a practical matter, it is advisable to employ automatic modulation control means adjusted to limit the maximum percentage of modulation to about 96 per cent in order to have a margin of safety in avoiding cut-off periods and harmonic voltages which might otherwise be produced by overmodulation. This limit of the depth of modulation is represented in Fig. 1 by the broken line L—L which, in a preferred embodiment of the invention, is only 4 per cent above the zero reference line Z—Z. In Fig. 1, the margin of safety, which is the distance between the broken line L—L and the zero reference line Z—Z, is indi-

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cated by the arrow A. Thus, when the modulation envelope E dips down toward its zero reference line Z—Z, it is desirable to employ some control means which will prevent the modulation envelope E from going below the preassigned limit represented by the broken line L—L. Accordingly, a control circuit for performing this function is illustrated in Fig. 2.

The preferred embodiment of the invention is shown in Fig. 2 which represents a radio transmitter, which is for the most part of conventional design, having a class B or class C radio frequency amplifier. The conventional design has, however, been modified to include the automatic modulation control circuit as will appear from the following description of the operation of the station. In Fig. 2, a signal source M, such as a microphone, supplies audio frequency signal voltage of varying intensity, which may be either speech currents or telegraph signals or both. The signal source M is connected by a transformer T₁ to an audio frequency electronic amplifier VA of variable gain comprising two tubes V₁ and V₂ each having at least one control electrode. The amplifier VA also includes means described hereinafter for varying the gain of the tubes V₁ and V₂. The output of the amplifier VA is coupled by another transformer T₂ to a second audio frequency amplifier AA. The resulting output is superimposed by means of a third transformer T₃, upon the voltage supplied by the battery B to the conductor C leading to the radio frequency portion of the equipment.

An oscillator O, which generates radio frequency carrier current, is coupled by means of a transformer T₄ to a radio frequency amplifier RA. The amplifier RA comprises an electronic tube V₃ having at least one control electrode to which the carrier current is applied. The conductor C carrying the amplified audio frequency signals is connected to the anode-cathode circuit of the tube V₃ for modulating the amplitude of the carrier current in accordance with the varying amplitude of the signal voltage. Thus, the amplifier RA also serves as an electronic modulator and so can be considered as a combined amplifier and modulator. The output of the radio frequency amplifier RA is coupled by a transformer T₅ to the transmitting antenna A which radiates the signal-modulated carrier into space.

The automatic modulation control is effected by connecting a grounded resistor 1 to the cathode of tube V₃ by means of a conductor 2. Another conductor 3 is connected to the conductor 2 so that there is produced in the conductor 3 a fluctuating voltage which is representative of, or proportional to, the modulation envelope. This fluctuating voltage is conveyed by the conductor 3 to the cathode of a control triode 4. The grid of the control triode 4 is supplied with a negative bias voltage obtained from a bias battery 5. The value of this bias voltage is adjusted by a potentiometer 6 to an amount which will bias the triode 4 to cut-off when the voltage drop in resistor 1 is greater than an assigned minimum value.

When the value of the voltage derived from the cathode resistor 1 falls below the assigned minimum value due to the modulation envelope approaching its zero reference line Z—Z, the plate circuit of triode 4 becomes conductive. The anode-cathode current which will now flow through the tube 4 will draw current over a conductor 7 from a second resistor 8 which is connected to the control grids of the tubes V₁ and V₂ in the audio

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frequency amplifier VA. This will add to the negative bias supplied by the battery 9 to the control grids of the tubes V₁ and V₂ and will consequently reduce the gain of the audio frequency amplifier VA. The condenser 10 across the resistance 8 serves to integrate the pulses of control voltage transmitted by the control tube and smooths them out so that the resulting reduction in gain of the amplifier VA will be the same on both the positive and negative sides of the zero reference line Z—Z thereby avoiding distortion of the audio frequency signals. The ratio of resistance 8 to condenser 10 may be adjusted for the particular type of signal to be transmitted. This reduction in the gain of the amplifier VA produces a corresponding reduction in the amplitude of the modulating voltage impressed upon the conductor C extending to the combined amplifier and modulator RA thereby preventing overmodulation of the carrier wave in a negative direction so that the modulation envelope will not dip down below the preassigned value indicated by the line L—L.

Thus, this automatic modulation control circuit will reduce the value of the modulating potentials applied to the carrier on those occasions when the modulation envelope dips downward toward its zero reference line Z—Z. The operation of this automatic modulation control circuit is dependent solely upon the proximity of the modulation envelope to its zero reference line Z—Z, the critical point of operation being predetermined by adjusting the potentiometer 6 to permit the control triode 4 to become conductive when the modulation envelope dips down toward the value indicated by the line L—L in Fig. 1. It is not necessary to determine the exact value of the carrier as this value may fluctuate at will without interfering with the operation of this automatic modulation control circuit. In other words, if the value of the carrier should fluctuate so that its amplitude becomes smaller than usual, a modulating potential of given amplitude would, when acting in a negative direction, bring the modulation envelope closer to its zero reference line Z—Z than would otherwise be the case. However, this would not interfere with the operation of the automatic control circuit which considers only the proximity of the modulation envelope to the zero reference line Z—Z. Thus, the automatic modulation control circuit becomes operative whenever the instantaneous amplitude of the modulated carrier wave becomes nearer to zero than a preassigned value.

What is claimed is:

1. In a radio transmission system having a source of variable signal voltage and a source of carrier waves with means for modulating the amplitude of the carrier waves in accordance with the signal voltage, an automatic modulation control circuit for preventing overmodulation of the carrier waves comprising means for deriving a fluctuating potential proportional to the instantaneous value of the modulation envelope of the modulated carrier waves, an electronic tube, means for applying said potential to one electrode of said electronic tube, a source of bias voltage, means for applying said bias voltage to another electrode of said electronic tube, and means for adjusting the value of said bias voltage to an amount which will bias said tube to cut-off when said fluctuating potential is greater than an assigned value..

2. In a radiant energy system having an audio frequency circuit and a radio frequency circuit,

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an electronic tube having one electrode connected into said audio frequency circuit and having another electrode connected into said radio frequency circuit, biasing means for biasing said tube short of cut-off, means for deriving an auxiliary bias voltage from said radio frequency circuit for normally biasing the tube beyond cut-off, means for reducing the value of the auxiliary bias voltage for rendering the tube conductive, and control means for regulating a portion of said audio frequency circuit in response to the flow of space current in said electronic tube.

3. In combination in a radio transmitting system, a source of signal current of varying amplitude, an electronic amplifier of variable gain for amplifying said signal current, said amplifier having a control grid, a source of carrier current, an electronic modulator having a cathode and a grid and an anode for modulating the amplitude of said carrier current in accordance with the varying amplitude of the signal current, first circuit means for applying said carrier current to the grid of the modulator, second circuit means for applying the amplified signal current to the anode of the modulator, said modulator also having a source of anode current supply, and automatic modulation control means for preventing excessive variations in the amplitude of the signal current and variations in the amplitude of the carrier current from causing said modulator to overmodulate the carrier current, said automatic modulation control means including a control tube having two electrodes, means for connecting one of said electrodes between the cathode of the modulator and the negative side of said source of anode current supply for obtaining a fluctuating potential representative of the modulation envelope of the modulated carrier current, and means for connecting the other of said electrodes to the control grid of said variable gain amplifier for controlling the gain of said amplifier.

4. In combination in a radiant energy system, a source of signal current of varying amplitude, an electronic amplifier of variable gain for amplifying said signal current, a source of carrier current, an electronic modulator having a cathode and a grid and an anode for modulating the amplitude of said carrier current in accordance with the varying amplitude of the signal current, first circuit means for applying said carrier current to the grid of the modulator, second circuit means for applying the amplified signal current to the anode of the modulator, third circuit means for connecting the cathode of the modulator to ground, a source of anode current having one side connected to the anode of the modulator and having its other side connected to ground, and automatic modulation control means for preventing excessive variations in the amplitude of the signal current and variations in the amplitude of the carrier current from causing said modulator to overmodulate the carrier current, said automatic modulation control means including an impedance connected in series between the cathode of the modulator and ground.

5. In combination in a radiant energy system, a source of signal current of varying amplitude, an electronic amplifier of variable gain for amplifying said signal current, a source of carrier current, an electronic modulator having a cathode and a grid and an anode for modulating the amplitude of said carrier current in accordance with the varying amplitude of the signal current, first circuit means for applying said carrier

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current to the grid of the modulator, second circuit means for applying the amplified signal current to the anode of the modulator, third circuit means for connecting the cathode of the modulator to ground, a source of anode current having one side connected to the anode of the modulator and having its other side connected to ground, automatic modulation control means for preventing excessive variations in the amplitude of the signal current and variations in the amplitude of the carrier current from causing said modulator to overmodulate the carrier current, said automatic modulation control means including an impedance connected in series between the cathode of the modulator and ground for developing a fluctuating potential across said impedance, a control tube for effecting variations in the gain of said variable gain amplifier, means for normally blocking the conductivity of said control tube by said fluctuating potential and for rendering said control tube conductive only when said fluctuating potential falls below an assigned value, and adjustable means for controlling said assigned value.

6. In combination in a radiant energy system, a source of signal current of varying amplitude, an electronic amplifier of variable gain for amplifying said signal current, a source of carrier current, an electronic modulator having a cathode and a grid and an anode for modulating the amplitude of said carrier current in accordance with the varying amplitude of the signal current, first circuit means for applying said carrier current to the grid of the modulator, second circuit means for applying the amplified signal current to the anode of the modulator, third circuit means for connecting the cathode of the modulator to ground, a source of anode current having one side connected to the anode of the modulator and having its other side connected to ground, automatic modulation control means for preventing excessive variations in the amplitude of the signal current and variations in the amplitude of the carrier current from causing said modulator to overmodulate the carrier current, said automatic modulation control means including an impedance connected in series between the cathode of the modulator and ground for developing a fluctuating potential across said impedance which is a function of the value of the modulation envelope of said modulated carrier current, and control means for reducing the gain of said variable gain amplifier whenever the value of said modulation envelope falls below a preassigned value, said control means comprising a control tube and means for normally blocking the conductivity of said control tube by said fluctuating potential and for rendering said control tube conductive only when said fluctuating potential is smaller than an amount corresponding to said preassigned value.

7. In combination in a radiant energy system, a source of signal current of varying amplitude, an electronic amplifier of variable gain for amplifying said signal current, a source of carrier current, an electronic modulator having a cathode and a grid and an anode for modulating the amplitude of said carrier current in accordance with the varying amplitude of the signal current, first circuit means for applying said carrier current to the grid of the modulator, second circuit means for applying the amplified signal current to the anode of the modulator, said modulator also having a source of anode current supply, and automatic modulation control means for prevent-

ing excessive variations in the amplitude of the signal current and variations in the amplitude of the carrier current from causing said modulator to overmodulate the carrier current, said automatic modulation control means including an impedance connected between the cathode of the modulator and the negative side of said source of anode current supply for deriving a fluctuating potential which is a function of the value of the modulation envelope of said modulated carrier current, a control tube, biasing means for biasing said tube short of cut-off, auxiliary biasing means for applying said fluctuating potential to an electrode of said control tube for blocking the conductivity of said tube except when said potential falls to a low value, and control means for varying the gain of said variable gain amplifier in response to the flow of space current in said control tube.

8. In combination in a radio transmitting system for transmitting signal modulated carrier current, a source of audio frequency signal current of varying amplitude, an electronic amplifier of variable gain for amplifying said signal current, a source of radio frequency carrier current, an electronic modulator for modulating the amplitude of the carrier current in accordance with the varying amplitude of the signal current, said modulator having a source of anode current supply, a first resistor, means for connecting said resistor between the cathode of the modulator and the negative side of said source of anode current supply for developing a varying potential across said resistor, a control tube having a cathode and an anode and a grid, a source of adjustable bias voltage connected to the grid of said control tube, a second resistor, means for connecting said second resistor into the anode circuit of said control tube for developing a biasing potential in said second resistor, first circuit means for utilizing the fall of potential in said second resistor to reduce the gain of said variable gain amplifier, and second circuit means for impressing the fall of potential developed across said electronic modulator between the cathode and grid of said control tube in such polarity as to block the flow of anode current therein except when the fall of potential in said first resistor drops below an assigned value.

9. In combination in a radio transmitting system, a source of audio frequency signal current of varying amplitude, an electronic amplifier of variable gain for amplifying said signal current, said amplifier having a control grid, a source of radio frequency carrier current, an electronic modulator having a cathode and a grid and an anode for modulating the amplitude of the carrier current in accordance with the varying amplitude of the signal current, first circuit means for applying said carrier current to the grid of the modulator, second circuit means for applying the amplified signal current to the anode of the modulator, third circuit means for connecting the cathode of the modulator to ground, a source of anode current having one side connected to the anode of the modulator and having its other side connected to ground, and automatic modulation control means for preventing excessive variations in the amplitude of the signal current and variations in the amplitude of the carrier current from causing said modulator to overmodulate the carrier current, said automatic modulation control

means including a first impedance connected in series between the cathode of the modulator and ground for deriving a first fluctuating potential which is a function of the value of the modulation envelope of said modulated carrier current, a control tube having a cathode and an anode, means for applying said first fluctuating potential to the cathode of said control tube, a second impedance connected to the anode of said control tube for developing a fluctuating biasing potential which varies inversely in respect to said first fluctuating potential, and means for applying said fluctuating biasing potential to the control grid of said variable gain amplifier for reducing its gain.

10. In combination in a radio transmitting system, a source of audio frequency signal current of varying amplitude, an electronic amplifier of variable gain for amplifying said signal current, said amplifier having a control grid, a source of radio frequency carrier current, an electronic modulator having a cathode and a grid and an anode for modulating the amplitude of the carrier current in accordance with the varying amplitude of the signal current, first circuit means for applying said carrier current to the grid of the modulator, second circuit means for applying the amplified signal current to the anode of the modulator, third circuit means for connecting the cathode of the modulator to ground, a source of anode current having one side connected to the anode of the modulator and having its other side connected to ground, and automatic modulation control means for preventing excessive variations in the amplitude of the signal current and variations in the amplitude of the carrier current from causing said modulator to overmodulate the carrier current, said automatic modulation control means including a first impedance connected in series between the cathode of the modulator and ground for deriving a first fluctuating potential which is a function of the value of the modulation envelope of said modulated carrier current, a control tube having a cathode and an anode and a grid, means for impressing said first fluctuating potential between the cathode and grid of said control tube in such polarity as to block the flow of anode current therein except when said first fluctuating potential falls below an assigned value, a source of adjustable bias voltage connected to the grid of the control tube for controlling said assigned value, a second impedance connected to the anode of said control tube for developing in response to the flow of anode current a fluctuating biasing potential which varies inversely in respect to said first fluctuating potential, means for applying said fluctuating biasing potential to the control grid of said variable gain amplifier for reducing its gain.

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