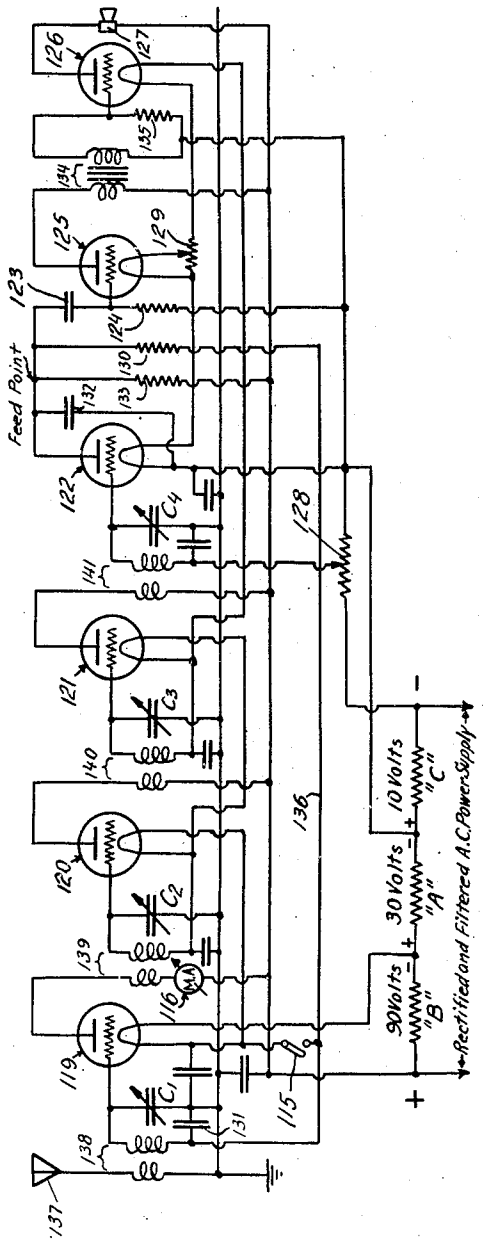
Sept. 27, 1932. H. A. WHEELER 1,879,861

VOLUME CONTROL

Original Filed July 7, 1927



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Patented Sept. 27, 1932 1,879,861

UNITED STATES PATENT OFFICE

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VOLUME CONTROL

Original application filed July 7, 1927, Serial No. 203,879, and in Great Britain July 3, 1928. Divided and this application filed November 10, 1930. Serial No. 494,558.

This invention relates to amplifiers and more particularly to amplifiers utilized in modulated carrier-current signaling systems wherein the limit of amplification is automatically maintained substantially at a predetermined level.

This application is a division of application Serial Number 203,879, filed July 7, 1927.

The principal object of this invention is to obtain a substantially uniform response from an amplifier in spite of variations in signal intensity or of the amplifier power supply.

When amplifiers are employed for amplifying a signal voltage, it becomes desirable for various reasons, to control automatically the amplitude of this amplified signal voltage. To this end the present invention provides means for effecting automatic amplification control. Such an arrangement, for example, is particularly advantageous in radio receivers such as are employed for receiving broadcasting signals, because it prevents the overloading of the last amplifier stage of the receiver, which overloading would result in distortion of the reproduced signal, as well as in loud and harsh reproduction.

Another advantage of the invention resides in uniform reproduction of the amplified signal irrespective of whether the carrier-current signal is received from a nearby station or from a distant station, or from a high power or from a low power station, since it has been found in the case of former radio receivers that when the receiver was reproducing strong signals as from a nearby or high power station, the audibly reproduced signal was very loud, whereas when the signal was received from a distant or low power station, it was relatively weak, with the result that if signals were to be reproduced uniformly from both near and distant stations, and from high power and low power stations, it became necessary to readjust some volume control means in the receiver to compensate for these unequal signals.

It has been a common experience in the use of former radio receivers, that the reproduced signal was not uniform, due to the phenomenon of "fading", whereby the received signal occasionally or periodically became much weaker, or faded almost to the point of inaudibility. Since the present invention provides an amplifier which automatically compensates for inequalities in the received carrier-current, when fading takes place, the degree of amplification is correspondingly increased and the reproduced signal maintained at its former volume so that a listener is unaware that variation of the received carrier current signal is occurring. This automatic compensation for signal fading is especially advantageous in commercial radio-telephony and like systems.

In existing radio receivers in which operating current is derived from the municipal power system, it has been found that when there is considerable variation in the line voltage supply, the volume of the reproduced signal is not uniform. An additional advantage of the present invention is that of automatically compensating for such line voltage variations with the result that the reproduced signal is uniform in volume.

Still a further advantage is the saving in plate current which is automatically effected during the reception of the powerful signals, for the reason that this invention incidently provides means for reducing the plate current of one or more amplifying tubes as the signal strength increases.

The above advantages are attained in accordance with the present invention by employing in the signal receiver a rectifying, or detecting, device preceded by one or more stages of carrier frequency amplification and impressing the potential of a point in the detector output circuit upon a control circuit of the carrier frequency amplifier. This is preferably accomplished by connecting a point in the detector output circuit, preferably the anode, through an impedance, or carrier frequency filtering arrangement, to the control electrode of one or more carrier frequency amplifying tubes, which then acts as the volume controlling tube or tubes. The circuit is so arranged that the potential of the control electrode of the volume controlling tube is

normally negative with respect to its filament. An increase of the signal strength, then, increases the rectified signal component, thereby making the control element of the volume controlling tube more negative, thereby reducing the amplification.

A feature of the invention is the provision of a source of potential supply for the electrodes of the vacuum tubes, which source includes resistances across which voltages are developed, which voltages are applied upon the proper tube electrodes. By virtue of this arrangement, the detector cathode may be maintained at a potential considerably negative with respect to that of the cathode of the amplifier whose amplification it is desired to control and the output electrode of the detector may be maintained slightly negative with respect to said amplifier cathode. This relationship of the electrode potentials enables the automatic volume control circuit to properly operate.

The drawing illustrates a radio receiver operated by a source of rectified and filtered alternating current, the receiver comprising three stages of radio frequency amplification, a rectifier, or detector and two stages of audio-frequency amplification. The three radio frequency stages comprise three thermionic amplifiers, 119, 120 and 121 coupled in tandem, the output of tube 121 being coupled to a three-electrode detector tube 122, and the input of tube 119 being coupled to antenna 137. The tubes are coupled in a well-known manner by transformers 138, 139, 140 and 141, the secondary windings of which are tuned by variable condensers C_1, C_2, C_3, and C_4. The variable condensers are grounded to eliminate undesirable capacity effects and to enable the condensers to be ganged together and operated by a uni-control arrangement. The audio-frequency amplifier comprises vacuum tubes 125 and 126 coupled in tandem by an audio-frequency transformer 134, the secondary winding of which has shunted across it, a resistance 135, the effect of which is to improve the uniformity of amplification over the voice frequency range.

The output of tube 126 is connected to a loud speaker 127, or if desired, to some other type of receiving device, such as a meter or a telephone system. The first audio-frequency amplifying tube 125 is connected to the output of the detector through an audio-frequency network or impedance coupling, which transmits the audio-frequency signals to the audio amplifier. This coupling comprises a condenser 123 connected between the anode, or plate, of the detector and the control electrode, or grid, of the amplifier tube 125, and an impedance 124, capable of transmitting direct current connected between the same grid and a source of grid biasing voltage.

The anode potential is supplied to the plate of the detector through a resistance 133, which is connected between a source of anode potential and the detector plate.

There is provided a condenser 132 connected between the anode and cathode, or filament, of the detector, this condenser being adapted to by-pass the radio frequency without appreciably shunting off the detected signals. Condenser 132 acts in conjunction with resistance 133 to diminish the radio frequency voltage across the output of the detector.

The volume control comprises a resistance 130, one terminal of which is connected to the anode of the detector, at the point labeled "feed point" in the drawing, and the other terminal of which is connected by lead 136 to the lower end of the secondary winding of radio frequency transformer 138, thereby placing the grid of the radio frequency amplifier 119 at the same potential as the anode of the detector. A condenser 131 bridged between the lower end of the secondary winding of transformer 138 and ground, cooperates with resistance 130 to prevent the passage of radio frequency energy from the output of the detector to the input of the radio frequency amplifier.

The rectified and filtered alternating current power supply for the receiver has shunted across its output three resistances, "A", "B" and "C" series, across which are respectively derived filament, plate and grid "B", and "C" voltages for the receiver. The filaments or cathodes of the six vacuum tubes are connected in series across the "A" resistance of the rectified, filtered, source of power supply, giving a potential difference of 30 volts, this being the proper voltage when the normal filament voltage of each tube is five volts.

The filament of the audio-frequency amplifier tube 125 is shunted by potentiometer 129 which acts as a manual volume control. The anode potential for all the tubes is derived from a connection to the positive end of resistance "B". It should be noted that the cathode of the first radio-frequency tube 119 is connected to the positive terminal of the 30 volt "A-section" of the power source, and that the cathode of the detector tube 122, is connected to the negative terminal of this section. In consequence, when the voltage across resistance B is 90 volts, the voltage available in the plate circuit of the detector is 120 volts with respect to its filament, while that available in the plate circuit of the first radio frequency amplifier is 90 volts with respect to its filament. The value of resistance 133 is high and is so chosen that the D C voltage drop across it due to the normal plate current through it, is greater than 90 volts, thus placing the detector anode, or "feed point", at a negative potential with respect to the cathode of radio frequency amplifier 119. The grid biasing potential of the first radio frequency tube, then, is negative with

respect to its cathode. The volume controlling system is operative so long as the detector anode is negative with respect to at least a part of the filament of the amplifier 119. The large value of resistance 133 required by this circuit arrangement results in high sensitivity of the detector circuit.

It should be understood that the invention is not limited to the use of the voltage values herein expressed; but these values are given merely to indicate how good results may be obtained.

In the event that tubes having an indirectly heated cathode are used instead of those having an electric current heated filament cathode, as represented in the drawing, the same results may be obtained as in the system illustrated in the drawing, if the detector cathode is maintained at a negative potential with respect to the cathode of the volume control tube, or tubes.

There is provided in the plate circuit of tube 119 a milliammeter 116 for indicating the anode current of that tube. A switch 115 serves to connect the lead 136 to the cathode of tube 119 when desired. The functions of the milliammeter and of the switch will be more fully disclosed later.

To complete the description of the system illustrated in the drawing, certain design data, or constants, are given herewith. It should be understood, however, that these, as well as all other constants appearing in the present specification are mentioned merely by way of example in describing certain specific embodiments, which, in practice, should prove satisfactory, and are not intended to suggest any specific limitation as to the scope of this invention. Accordingly, condenser 132 may be of .0005 micro-farads; 131 of .1 micro-farads; 123 of .005 micro-farads; resistance 133 of .5 megohm; and 130 and 124 of 2 megohms each.

In the operation of this receiver, a signal received by the antenna 137 is successively amplified through the three radio frequency amplifier stages. The audio-frequency signals with which the radio frequency carrier wave is modulated, are then detected in a well-known manner by detector 122, which is a grid bias detector. The audio-frequency signals are successively repeated by audio-amplifying stages comprising thermionic amplifiers 125 and 126, after which they are reproduced as sound by loud speaker 127.

A detected signal current flowing through resistance 133 causes the plate of the detector to become less positive relative to its cathode, and hence causes the potential of the grid of radio frequency amplifier 119 to become more negative relative to its cathode, thus decreasing the amplification of this amplifier stage. The stronger the incoming signals become, the more negative becomes the grid of amplifier 119, and the more the amplification is reduced. Conversely, when the signals become weaker the amplification increases. The result of this is that the strength of the signals impressed upon the detector remains nearly uniform for widely different signal strengths.

The automatic volume control not only compensates for fluctuation in the strength of the incoming signals, but also compensates for variations in the line voltage of the alternating current power supply. A drop in the line voltage, for example, reduces the current through resistance 133, thereby reducing the negative potential on the grid of tube 119 and increasing the amplification. Conversely, the increase of power line current makes the grid of the first radio frequency amplifier more negative.

In this manner, the radio frequency voltage applied to the input of the rectifier detector is maintained at nearly constant predetermined value, and the volume of the reproduced signal is substantially uniform under all conditions. The degree of volume of the reproduced signal is then determined by adjustment of potentiometer 129, which controls the heating current in the filament of the first audio-frequency amplifying tube 125.

In adjusting the system for reception, it is necessary to determine the correct setting of the detector grid potentiometer 128. This adjustment should be made while there is no signal being received, as follows: First, the switch 115 is closed and the normal plate current of the tube 119 is noted on milliammeter 116. Then the switch is opened, thus placing the control circuit in operation. In general, the plate current of vacuum tube 119 will change when the switch is opened since the grid voltage of this tube is dependent upon the control circuit. By varying the grid voltage of the detector by means of potentiometer 128, the plate current of tube 119 is then adjusted to normal value, and the apparatus is ready for operation. Upon receipt of an amplified signal at the detector, the effect of the control circuit is to decrease the plate current through the milliammeter thereby reducing the amplification of the tube 119. When the receiver is tuned to the signal frequency a minimum amplification is required so the condition of resonance is ascertained by a minimum reading of the milliammeter.

It is possible to employ in place of the three-electrode detector, a two-electrode rectifier or detector, in the manner set forth in my above mentioned application, Serial Number 203,879. An advantage of the three-electrode detector over the two-electrode type is its greater response to weak signals.

It is understood that the invention is not limited to the specific embodiment herein disclosed, but may be advantageously em-

ployed in other types of amplifiers. The volume control operates particularly well when used with a radio frequency amplifier having the grid-plate capacity neutralized. Such neutralization may be effected by connecting a condenser of small capacity between a point in the output transformer and the grid of the tube; the neutralization system is more fully explained in U. S. Patents 1,489,228 and 1,533,858 issued to Hazeltine. The neutralization is particularly valuable in combination with the present invention in that it increases the effectiveness of the amplification control, because such neutralization prevents radio frequency energy from passing through the grid plate capacity of the tube. Thus the relay action of the tube is almost entirely subject to the control by grid bias voltage provided in accordance with this invention.

The volume controlling system may, if desired, be applied to more than one amplifying stage, in the manner disclosed in my co-pending application Serial Number 203,879, filed July 7, 1927, of which this application is a division.

I claim:

1. In a signaling system, a vacuum tube amplifier having a cathode and a control electrode, a vacuum tube detector coupled to said amplifier, said detector having more than two electrodes including an output electrode, means for maintaining said output electrode normally slightly negative relative to at least part of said amplifier cathode, means for causing said output electrode to become more negative in the presence of an amplified signal, and a direct current connection between said control electrode and said output electrode whereby the amplification of said amplifier is regulated automatically.

2. In a signaling system, a vacuum tube amplifier having a cathode and a control electrode, a three-electrode vacuum tube detector coupled to the output of said amplifier, said detector having an output electrode which is normally slightly negative relative to at least part of said amplifier cathode and which becomes more negative in the presence of an amplified signal, and a direct current connection between said control electrode and said output electrode whereby the amplification of said amplifier is regulated automatically.

3. In a signaling system a vacuum tube amplifier having a cathode and a grid electrode, a three-electrode vacuum tube detector coupled to said amplifier, said detector having a cathode and a plate electrode, which detector cathode is greatly negative relative to said amplifier cathode, and which plate electrode is normally slightly negative relative to said amplifier cathode but becomes more negative in the presence of an amplified signal, and a direct current connection between said grid and said plate whereby the amplification of said amplifier is regulated automatically.

4. In a signaling system, a carrier frequency amplifier comprising a repeating element having a cathode and a control electrode, a three-electrode thermionic detector connected to said carrier frequency amplifier, and an audio-frequency amplifier connected to said detector, said detector having a cathode and a plate electrode which detector cathode is greatly negative relative to said amplifier cathode, and which plate electrode is normally slightly negative relative to said amplifier cathode, but becomes more negative in the presence of an amplified signal, a connection to said audio amplifier, and a direct current connection between said control electrode and said plate, whereby the amplification of said amplifier is regulated automatically.

5. In a signaling system a vacuum tube amplifier having a filament and a grid electrode, a three-electrode vacuum tube detector coupled to said amplifier, said detector having a filament and a plate electrode, which detector filament is connected in a series circuit with said amplifier filament and is substantially negative relative to said amplifier filament, and which plate electrode is normally slightly negative relative to said amplifier filament, but becomes more negative in the presence of an amplified signal, and a direct current connection between said grid and said plate whereby the amplication of said amplifier is regulated automatically.

6. In a signaling system, a carrier frequency amplifier comprising a repeating element having a cathode and a control electrode, a three-electrode thermionic detector and an audio frequency amplifier, said detector having a filament and a plate electrode, which detector filament is connected in a series circuit with said amplifier filament and is substantially negative relative to said amplifier filament, and which plate electrode is normally slightly negative relative to said amplifier filament, but becomes more negative in the presence of an amplified signal, and a direct current connection between said control electrode and said plate whereby the amplification of said amplifier is regulated automatically.

7. A radio receiver comprising a radio frequency amplifier, a detector and an audio frequency amplifier, said amplifiers and detector comprising thermionic space discharge devices each having a cathode, anode and control electrode, the anode of said detector being connected through an impedance to the control electrode of one of said radio frequency amplifying devices for controlling its amplification in accordance with the detector output, said cathodes being connected

in series to a source of heating current, the potential of the cathode of said controlled radio frequency space discharge device being more positive than that of the cathode of said detector whereby said detector may operate with its anode at a negative potential with respect to the cathode of said controlled radio frequency space discharge device.

In testimony whereof I affix my signature.

HAROLD A. WHEELER.