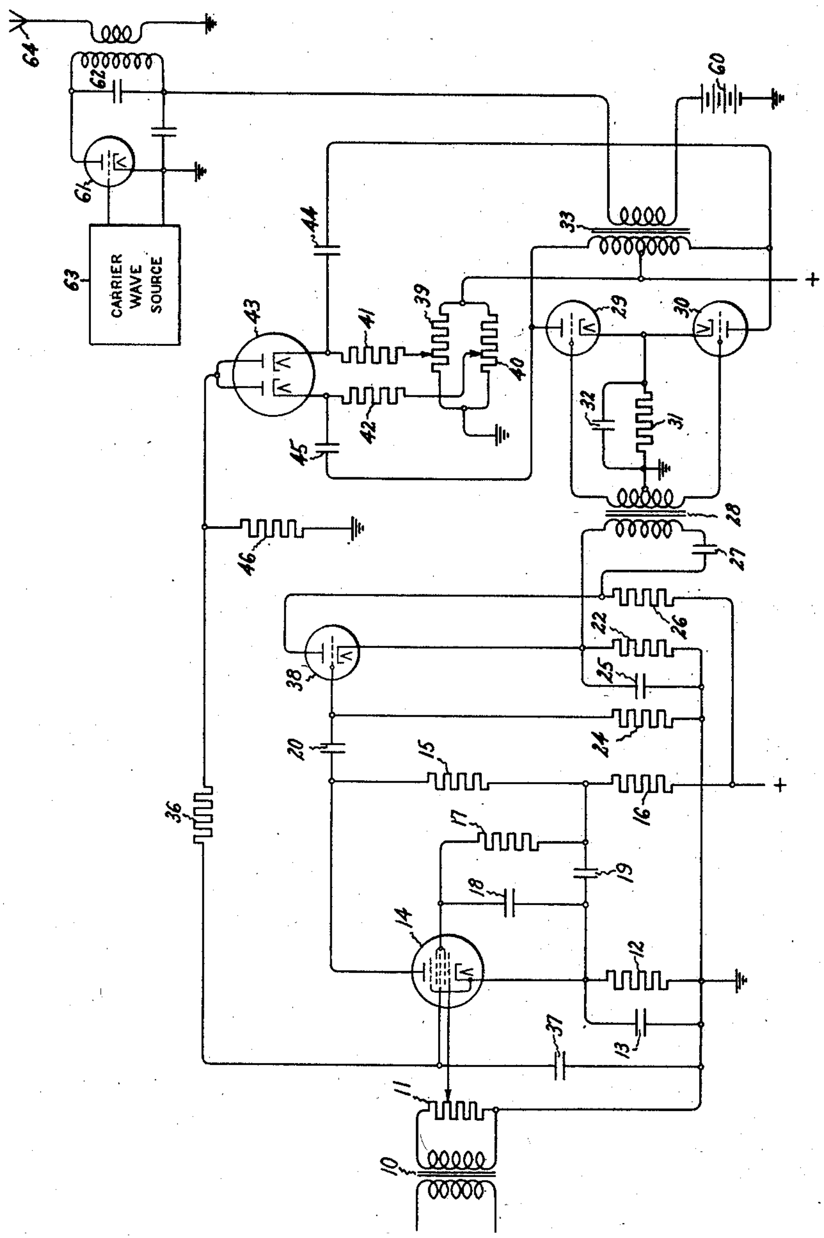
June 9, 1942. G. M. BROWN 2,285,896

AUTOMATIC AMPLIFICATION CONTROL

Original Filed June 13, 1939



Inventor:
George M. Brown,
by Harry E. Dunham
His Attorney.

Patented June 9, 1942 **2,285,896**

UNITED STATES PATENT OFFICE

2,285,896

AUTOMATIC AMPLIFICATION CONTROL

George M. Brown, Scotia, N. Y., assignor to General Electric Company, a corporation of New York

Original application June 13, 1939, Serial No. 278,854. Divided and this application July 23, 1941, Serial No. 403,658

5 Claims. (Cl. 179—171.5)

This invention relates to electron discharge amplifier circuits.

This application is a division of my former application, Serial No. 278,854, filed June 13, 1939, and assigned to the same assignee as the present application.

It has been a problem in the art of communication by modulated carrier waves to obtain a maximum amount of modulation at all times in order to use the carrier wave most efficiently. It is desirable to amplify signal waves with which a carrier is to be modulated in such a way that the average modulation depth approaches 100 per cent as nearly as possible while retaining the fidelity of the signal waves. The design of my amplifier is such that signal waves are amplified linearly up to some arbitrary amount which modulates the carrier wave at an arbitrary depth, such as 90 per cent, while for signal waves of greater level than this arbitrary value the amplification is reduced so that the output of my amplifier increases very slowly above this arbitrary value. It is accordingly an object of my invention to provide an improved and simplified audio amplifier of conventional construction which is adapted to supply amplified signal energy to any utilization circuit and at the same time controls the amount of amplification in response to the relation of the amplified wave to an arbitrary level.

In certain types of amplifiers, such as those used with transmitters of frequency modulated waves, or phonograph recording apparatus and the like, it is desirable to provide means responsive to peaks of the signal waves of either polarity to control the amplification of the amplifier. In the case of frequency modulated waves the available band width of the receiver is definitely limited and the frequency modulated waves transmitted must not exceed this band width in their frequency changes. In phonographic recording the available groove width must not be exceeded on either side. Many communication systems have similar limitations. It is therefore an additional object of my invention to provide improved amplifying apparatus continuously adjusted in amount of amplification in response to the level of peaks of alternating voltage of either polarity.

The features of my invention which I believe to be novel are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying drawing in which the single figure is a circuit diagram illustrating schematically an audio amplifier embodying my invention.

Referring to the figure, a suitable source of audio frequency waves is represented by an input transformer 10, across the secondary of which a voltage dividing resistance 11 is connected. The primary of the transformer 10 may be suitably supplied with audio frequency waves from a microphone or a phonograph pickup, or the like. One end of the resistance 11 is connected to ground and is also connected through a cathode bias resistor 12 and a bypass condenser 13 to the cathode of a pentagrid tube 14. The movable contact of the resistance 11 is connected to the first grid of tube 14, which serves to amplify voice waves applied through transformer 10. The anode of the tube 14 is connected through a resistor 15 and a resistor 16 to a suitable source of operating potential. The second and fourth grids of the tube 14 are screen grids and are connected through a resistor 17 to a point between resistors 15 and 16 in order to provide the screen grids with the proper biasing potential. These two screen grids are connected by a condenser 18 to the cathode of tube 14. Another condenser 19 connects the point between resistors 15 and 16 with the cathode of tube 14. The fifth grid of tube 14 is connected directly to the cathode and acts as a suppressor grid.

Voice waves applied to the first or control grid of the tube 14 through the transformer 10 produce corresponding variations in anode potential of the tube 14 due to the variations in voltage drop through resistor 15. These variations in voltage are coupled by a condenser 20 to the control grid of a triode tube 38. The cathode of the tube 38 is connected to ground through cathode biasing resistor 22. A grid resistor 24 is connected from the grid of tube 38 to ground to provide proper bias potential for the grid. Resistor 22 is shunted by a bypassing condenser 25. The anode of the tube 38 is connected through a resistor 26 to a suitable source of operating potential.

The grid of tube 38, which is supplied with voltage variations by condenser 20, causes voltage variations on the anode of tube 38 due to the voltage drop through the resistor 26. These anode voltage variations are coupled through a condenser 27 to the primary of a transformer 28. The other end of the transformer primary is connected to the cathode of tube 38. The ends of the secondary of transformer 28 are connected respectively to the grids of a pair of tubes 29 and 30 arranged in push-pull relation. The secondary of the transformer 28 has a center tap connection which is grounded and is also connected through a resistor 31 shunted by a bypass condenser 32 to the cathodes of the tubes 29 and 30. The anodes of the tubes 29 and 30 are connected respectively to the ends of the primary of a transformer 33. A center tap connection of the primary of transformer 33 is connected to a suitable source of anode potential. The secondary of the transformer 33 is adapted to supply amplified audio waves to any suitable device. This device may, for example, be the modulation stage in a radio transmitter, with which my invention is particularly useful.

A typical plate modulated transmitter, as illustrated, may include a source 60 of operating potential for a carrier wave power amplifier device 61. The negative terminal of the source 60 is grounded and the positive terminal is connected through the secondary of transformer 33 and through a tuned circuit 62 to the anode of the device 61, whose cathode is grounded. A carrier wave source 63 impresses a carrier wave upon the device 61 to be amplified therethrough by an amount governed by the operating potential supplied through transformer 33. The amplified carrier wave in the tuned circuit 62 is radiated from an antenna 64.

A pair of voltage dividing resistances 39 and 40 are connected across a suitable source of direct current. The sliding contact of the resistance 39 is connected through a conductive impedance 41, which is shown for convenience as a pure resistance, to the cathode of a diode element of a tube 43. Similarly the sliding contact of the resistance 40 is connected through a conductive impedance 42, also shown as a resistor, to the cathode of a second diode element of the tube 43. The cathode of the first diode is connected through a condenser 44 to the anode of tube 30. The cathode of the other diode is connected through a similar coupling condenser 45 to the anode of tube 29.

The anodes of these two diodes are connected together and to ground through a resistor 46. These anodes are also connected through resistor 36 to the third grid of tube 14, which is coupled by the condenser 37 to ground.

In operation, under the condition when no signal is being amplified, the cathodes of the tube 43 are maintained at positive potentials with respect to ground by amounts equal to the voltage from the sliding contacts of the respective resistances 39 and 40 to ground. The anodes of tube 43 are maintained at ground potential by resistor 46.

When signals are amplified by the arrangement, the voltage variations of the anodes of tubes 29 and 30 are impressed on the cathodes of tube 43. These voltage variations due to signals make the cathodes of tube 43 less positive during certain portions of the signal wave. When these cathodes become negative due to a signal of greater level than that necessary to overcome the respective positive bias voltage produced by resistances 39 and 40, the tube 43 passes current and the anodes of tube 43 become negative with respect to ground. This produces a similar negative voltage on the third grid of tube 14 and reduces the amplification thereof.

Although there is little capacity between the anode and cathode of a diode, so that feedback is a minimum through such capacity in the tube 43, even such minimum feedback produces through each diode some alternating potential on the third grid of tube 14. Alternating potential of one phase is fed back from tube 29 through condenser 45, one half of tube 43, and resistance 36 to the third grid of tube 14, but alternating potential of opposite phase is fed back simultaneously from tube 30 through condenser 44, the other half of tube 43, and resistance 36 to the third grid of tube 14. These two alternating potentials of opposite phase produce substantially complete neutralization of each other on the third grid of tube 14, and thus both regenerative and degenerative effects in the grid control connections are avoided.

The proper adjustment of my amplifier for use in a radio transmitter is such that the output of transformer 33 rises linearly in accordance with the input to transformer 10 up to a critical value at which the output from the transformer 33 is sufficient to modulate the carrier wave with a predetermined depth, such, for example, as 90 per cent. Any other suitable depth may be chosen as desired. The operation of my amplifier then prevents any great rise in output from transformer 33 above this value and accordingly reduces tremendously the possibility of over-modulation. With an amplifier of this type there can be no appreciable distortion of the modulated carrier wave with corresponding radiation at undesired frequencies, since over-modulation may be completely prevented except for momentary transients.

It has been found that some music and most speech, when translated into electric wave energy, has greater peak amplitudes of one polarity than of the other. Since the phenomenon called "over-modulation" with the accompanying radiation of spurious signals is due principally to flattening of the carrier envelope on the zero axis rather than by extension of the maximum carrier amplitude beyond the level at twice the amplitude of the carrier when unmodulated, it is desirable that such higher peaks of a signal wave produce the positive modulation peaks or maximum carrier amplitudes and that the smaller peaks of opposite polarity produce the negative modulation peaks of the carrier. The provision of such operation allows more energy to be radiated for a given signal wave, assuming maximum permissible modulation, with a corresponding increase in efficiency. It is desirable, therefore, to secure such operation, to pole the output from transformer 33 to insure that the peaks of higher polarity produce positive modulation peaks. It is, of course, first desirable to pole the input to transformer 10, from the microphone or the like, so that the reduction of amplification shall be initiated in response to the lower peaks of the signal wave.

It should be noted particularly that tube 29 amplifies signal voltage swings of one polarity and tube 30 those of the other. Hence, if the signal peaks of either polarity increase more than predetermined amounts, the tube 43 passes current in the corresponding diode element and the amplification of tube 14 is reduced. It should also be noted that the predetermined levels at which the two diode elements pass current may be separately adjusted by the sliding contacts of the two resistances 39 and 40. They are preferably adjusted in proportion to the magnitude of alternating voltage on the respective anodes of tubes 29 and 30 for the particular type of signal being amplified.

While I have shown a particular embodiment of my invention, it will, of course, be understood that I do not wish to be limited thereto, since different modifications may be made both in the circuit arrangement and instrumentalities employed, and I aim by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In combination, an amplifier having a balanced output circuit, a pair of rectifiers, said rectifiers having a direct current load resistance, separate means to bias each rectifier to a normally non-conductive condition, means to supply alternating potential from the respective opposite sides of said output circuit to a corresponding one of said rectifiers, whereby each rectifier becomes conductive when its respective bias is overcome by said alternating potential and direct current tends to flow in the load resistance, and means to control the amplification of said amplifier in response to the potential on said resistance, the bias supplied to the different rectifiers by said biasing means being proportioned in accordance with the magnitude of alternating voltage on the respective sides of the output circuit.

2. Modulating means for modulating the intensity of a carrier wave in accordance with a signal, said means comprising a signal amplifier having separate rectifiers for rectifying positive and negative half cycles of said signal, a separate bias potential source tending to maintain each of said rectifiers in non-conducting condition, whereby current flows in the respective rectifiers only when said positive and negative half cycles exceed the corresponding bias potentials, and means to reduce the amplification of said amplifier in response to current flowing in either of said rectifiers, said positive half cycles being of greater intensity than said negative half cycles and said modulating means being arranged to decrease the intensity of said carrier in response to negative half cycles of signal, said bias potential corresponding to said negative half cycles being adjusted substantially to prevent decrease of said carrier wave to zero intensity, and said bias potential corresponding to said positive half cycles being adjusted to prevent increase of said carrier above a predetermined intensity.

3. In an electron discharge amplifying device including a balanced circuit, a pair of rectifiers connected separately to impress a direct potential on a point, separate means to bias each rectifier to a normally non-conductive condition, means to supply alternating potential from the respective opposite sides of said balanced circuit to a corresponding one of said rectifiers, whereby each rectifier becomes conductive when its respective bias is overcome by said alternating potential and direct potential is impressed on said point, and means to control the amplification of said amplifier in response to the potential on said point, the bias supplied to the different rectifiers by said biasing means being proportioned in accordance with the magnitude of alternating voltage on the respective sides of said balanced circuit.

4. In an electron discharge amplifying device including a balanced circuit, a pair of unidirectional conducting circuits, separate means in each of said unidirectional circuits to bias said circuits to a normally non-conductive condition, means to supply alternating potential from the respective opposite sides of said balanced circuit to a corresponding one of said unidirectional circuits, whereby each of said unidirectional circuits becomes conductive when its respective bias is overcome by said alternating potential and tends to maintain a point at a direct potential, and means to control the amplification of said amplifying device in response to the direct potential on said point produced by either of said unidirectional conducting circuits.

5. In a system having a carrier wave source, a signal source, and amplifying means for modulating the intensity of the carrier wave from said carrier wave source in accordance with the signal from said signal source, the combination of a pair of rectifiers, separate means to bias each rectifier to a normally non-conductive condition, said biasing means being separately adjustable whereby conduction occurs in each rectifier at a different potential, means to supply alternating potential from said amplifying means to one of said rectifiers and to supply alternating potential of opposite phase from said amplifying means to the other of said rectifiers, whereby each of said rectifiers becomes conductive when its respective bias is overcome by the corresponding alternating potential and means to control the amplification of said amplifying means in response to the conduction of current through either of said rectifiers, whereby either increase or decrease of intensity of said carrier wave may be limited to predetermined differently adjustable limits.

GEORGE M. BROWN.