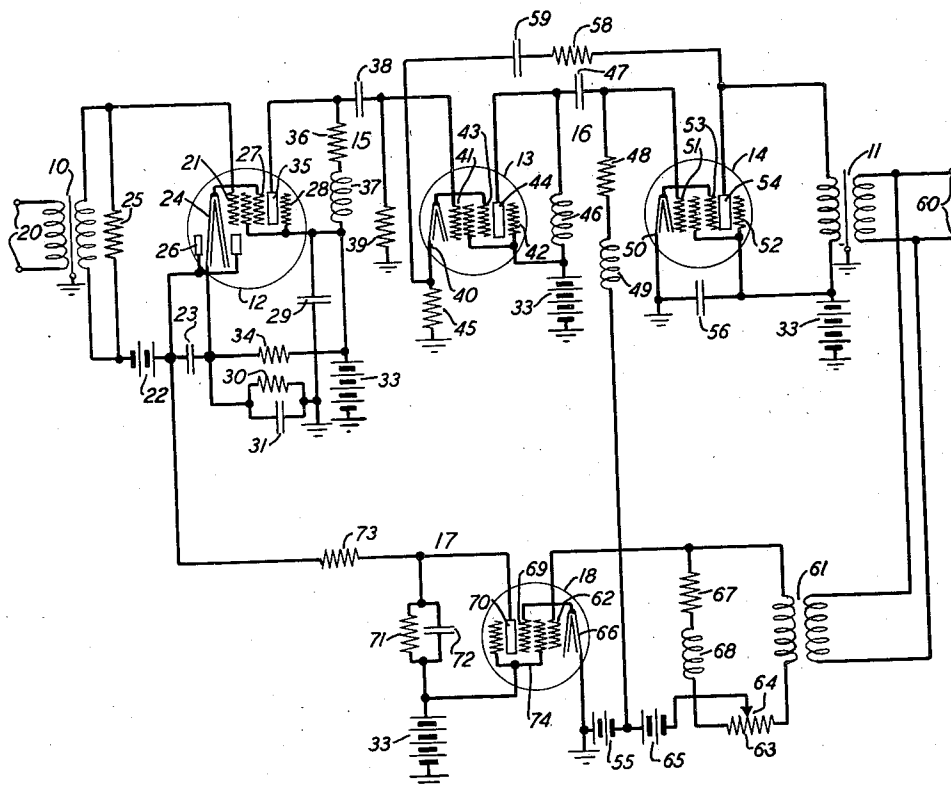


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J. O. EDSON
AMPLIFYING SYSTEM
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INVENTOR
J. O. EDSON
BY *H. A. Burgess*
ATTORNEY

UNITED STATES PATENT OFFICE

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AMPLIFYING SYSTEM

James O. Edson, Great Kills, N. Y., assignor to
Bell Telephone Laboratories, Incorporated, New
York, N. Y., a corporation of New York

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This invention relates to an electric wave amplifying system, and more particularly, to an automatic volume control arrangement therefor.

5 An object of this invention is to satisfy the need for an amplifying system that will amplify signal waves over a wide range of frequencies and that will have a substantially constant output regardless of relatively large variations in its input.

10 A feature of the invention comprises an amplifying system in which the signal output operates a control device associated with an amplifying device of the system to vary in predetermined manner the gain of the amplifying device in accordance with variations in such signal output
15 whereby the amplifying system's output is substantially constant for wide variations in its input.

Another feature comprises such an amplifying system in which the control device comprises an
20 electron discharge device operated as a detector with a very high grid bias and circuit arrangement such that the working point of the detector is at the point of maximum slope of the plate current versus alternating current input characteristic
25 of the detector.

A further feature comprises such an amplifying system in which any tendency for the control grid of the amplifying device to go positive because
30 the anode of the control tube is at a higher potential than the amplifying device cathode, is neutralized.

Other and further features will be evident from the general and detailed description which follows.

35 In accordance with the invention, the amplifying system comprises a three-stage amplifier having a pentode-diode for the first stage and pentodes for the other two stages, the stages being coupled through interstage networks or circuits
40 having a substantially flat frequency characteristic over the range of frequencies to be amplified, for example, up to 150 kilocycles. When operating at normal load, the output of the amplifier is maintained substantially constant for relatively
45 large variations in the amplifier input, by means of a control tube and associated circuit. The control tube is a pentode, preferably, with its control grid normally biased to a negative potential much greater than that required for plate
50 current cut-off, and its cathode negative relative to the potential above ground of the cathode of the first stage and controlled tube of the amplifier. The potential placing the cathode of the latter tube at the desired level above ground is
55 obtained through a potential divider from the

plate supply common to all of the tubes. The anode of the control tube is connected to the grid circuit of the controlled tube. When the signal input, i. e., the amplifier output, is sufficiently great to overcome the control tube grid
5 bias sufficiently to permit plate current of an order reducing the plate potential to a point where it is slightly less positive than, or more negative with respect to, the cathode of the first
10 tube of the amplifier, tendency toward increases in the amplifier output results in increase in the negative bias on the control grid of the amplifier's first tube, and a lowering of the gain of the amplifier so that the amplifier output returns to the
15 original level from which it departed because of an increase in the input to the amplifier. A tendency to a decrease in the amplifier output from its desired level causes the control tube anode potential to increase, since the plate current decreases, and the control grid bias of the controlled tube to become less negative whereby the
20 gain of the controlled tube and of the amplifier increases to maintain the amplifier output at the desired level.

When the amplifier output is such that no
25 plate current flows in the control tube, or the plate current is such that the anode potential of the control tube is more positive than the cathode of the controlled tube, the control grid of the controlled tube may be driven positive. To
30 prevent this, the diode incorporated in the first tube of the amplifier is utilized, the anode of the control tube being connected to the anodes of the diode to produce a potential drop between the control tube anode and the point at which it is
35 connected to the grid circuit of the controlled tube.

A more complete understanding of this invention will be obtained from the detailed description which follows, taken in conjunction with the appended drawing, the single figure of which shows
40 an electric wave amplifying system embodying the invention.

The single figure shows a three-stage amplifier comprising an input transformer 10, an output
45 transformer 11, electron discharge devices 12, 13, 14, interstage coupling circuits or networks 15, 16, and a control circuit 17 including an electron discharge device 18. The device 12 is a pentode-diode tube, for example, an R. C. A. type 6B7
50 tube, devices 13 and 14 are pentodes, for example, Western Electric type 310A and 311A, respectively, and device 18 is a pentode, for example, Western Electric type 310A, each tube having an indirectly heated cathode.
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The primary winding of the input transformer is connected to the input terminals 20. Its secondary winding is connected to the control grid 21 of tube 12, and through grid biasing battery 22 and high frequency by-passing condenser 23 to the cathode 24. A resistance 25, of suitable size for the transformer, is connected across the secondary winding so that the amplifier input impedance approximates a pure resistance. The cathode 24 is also the cathode for the diode forming a part of tube 12, the condenser 23 being connected between the cathode and the diode plates 26. The suppressor grid 27 is connected directly to the cathode. The screen grid 28 is connected through condenser 29 to the ground end of the parallel connected resistance 30 and condenser 31 in the cathode lead, and to battery 33, which constitutes a common plate and screen grid supply for the tubes of the amplifier. A resistance 34 is connected between the cathode 12 and the battery 33. The anode or plate 35 is connected through resistance 36 and coil 37 to battery 33.

The tubes 12, 13 are coupled through an impedance interstage or coupling circuit 15 comprising the output circuit of device 13, coupling condenser 38 and input resistor 39 of the second stage of the amplifier, the elements 36, 37, 38, 39 being proportioned to have a substantially flat characteristic over the frequency range being amplified.

The electron discharge device 13, comprises a cathode 40, control grid 41, screen grid 42, suppressor grid 43 connected directly to the cathode, and anode 44. Grid biasing potential is provided by cathode resistor 45. Battery 33 supplies positive potential for the screen grid, and through output coil 46 for the anode.

The tubes 13 and 14 are coupled through an impedance interstage or coupling circuit 16 comprising the output circuit of tube 13, coupling condenser 47 and input resistor 48 and coil 49 of tube 14, the elements 46, 47, 48 and 49 being proportioned to have a substantially flat frequency characteristic over the frequency range being amplified.

The tube 14 comprises a cathode 50, control grid 51, screen grid 52, suppressor grid 53 connected directly to the cathode, and anode 54. Control grid biasing potential is provided by battery 55. Condenser 56 is connected between the cathode and the screen grid, the latter being connected to the positive pole of battery 33. The anode 54, also, is connected to battery 33 through the primary winding of the output transformer 11, the secondary winding of which is connected to output terminals 60. Connected between the anode of tube 14 and the cathode end of resistor 45, is a resistance 58 and a condenser 59 in series.

The primary winding of a transformer 61 is connected across the secondary winding of the output transformer. The secondary winding of transformer 61 is connected to the control grid 62 of tube 18 and through potentiometer 63, slider 64 and serially connected biasing batteries 65 and 55 to the cathode 66. A resistance 67 and coil 68 are connected between the control grid and the potentiometer, the resistance of 63 being small relative to that of 67 and its variation permitting a slight control on the input voltage to the control tube. The suppressor grid 69 is connected directly to the cathode and the screen grid 74 is connected to the positive pole of battery 33. Anode 70 is connected through the

parallel arranged resistance 71 and condenser 72 to battery 33 and through filtering resistance 73 to the diode plates terminal of the condenser 23.

The amplifier described is adapted to have its input terminals connected to a source of high frequency signal wave, for example, to the output of an oscillator, to amplify the received signal with a substantially flat frequency characteristic over a desired frequency range, for example, up to 150 kilocycles, and to supply at its output terminals the amplified signal, the output voltage across the output terminals being constant for wide variations of the input voltage, i. e., the output will vary less than .01 decibel for a variation of 1 decibel in the input.

This result is attained by the use of a control circuit including a grid bias detector having a very high grid bias together with a circuit arrangement such that the working point is at the point of maximum slope of the plate current versus alternating current input characteristic of the detector.

The negative bias on the control grid, provided by batteries 55 and 65, is very much higher than that required to bias the tube 18 to cut-off. The peak input to the tube must, therefore, be considerably greater than extinction voltage of the tube before any plate current flows in the cathode-anode circuit. When the amplifier is in normal operation, and voltage at the output terminals of the amplifier rises above the desired level, the peak input potential will overcome the bias on the control grid 62 and the detector will draw current. This will result, because of current flow through resistance 71, in the potential between the anode 70 and ground becoming less positive or more negative than when there was no effective signal input to the tube 18. This variation may be and is used to vary, or, specifically, to increase the bias on a remote or controlled tube, specifically tube 12, and thus to reduce its gain, and therefore, that of the amplifier, to lower the output signal to within the preassigned limits.

To obtain this control, however, the cathode of tube 18 should be negative with respect to that of tube 12. This result is obtained in this amplifier by the connection of cathode 66 to ground, and the raising of the potential of the cathode 24 of tube 12 above ground by means of a potential divider across the plate voltage supply 33. Resistances 30 and 34 constitute this potential divider. With the cathode 24 an appreciable potential above ground with respect to cathode 66, it is apparent that if sufficient signal input is applied to the control grid 62, the anode 70 of tube 18 will become negative with respect to the cathode of tube 12.

So far as operation with a steady applied signal is concerned, the arrangement just described would be sufficient to provide satisfactory automatic volume control. It is not desirable, however, to permit the control grid of the controlled tube to be driven positive when the signal output of the amplifier is insufficient to cause the control tube to operate. The diode circuit is provided for this contingency as is the biasing battery 22 which provides a small initial negative potential to the grid. If the signal output of the amplifier is insufficient to cause plate current to flow in the control tube, the anode voltage of tube 18 rises to a value more positive than that of the cathode of tube 12 and current begins to flow to the diode anodes 26 of the tube 12. Since the resistances 73 and 71 are

large compared to the resistance of the diode for positive voltage applied to the diode anodes 26, the drop across the diode is small. Thus the potential applied to the grid 21 of tube 12 does not become positive with respect to its cathode at any time. The resistances 71 and 73 are much larger than resistance 30 so that the current to the diode does not produce any noticeable change in potential across resistance 30. If the signal input increases to the point where plate current flows in the control tube, the potential difference between the diode plates and the cathode decreases. As the plate current in the control tube increases, the potential of anode 70 eventually becomes exactly the same as that of cathode 24. Signal input causing greater current flow produces no further effect on the diode, since the diode plate potential falls below that of cathode 24, and control of the grid bias of tube 12 begins. Thus, under actual working conditions, when the control circuit is controlling the output of the amplifier, the diode has no effect on the amplifier performance, but is effective, when the control tube is not in control, to prevent the control grid of tube 12 from swinging positive. The arrangement described permits tube 18 to be operated in a range such that the slope of the plate current versus alternating current input characteristic is quite large, increasing the direct current amplification through the control circuit and increasing the degree of control obtained.

The serially connected resistance 58 and condenser 59 are proportioned to feed back a part of the output of the tube 14 to the cathode resistor 45, in such sense that the gain around the last two stages of the amplifier is reduced to stabilize the gain, and to reduce distortion and noise, in accordance with the teachings of H. S. Black Patent 2,102,671, issued December 21, 1937.

When a very stable source of plate potential is available, the use of the voltage divider to supply the potential difference between the cathodes of tubes 12 and 18 is satisfactory. If the plate supply is not very stable, it may be necessary to use a dry cell battery to maintain the cathode of tube 18 negative with respect to that of tube 12. This can always be done with reasonable satisfaction because the current drawn by the control tube is never very large.

In an amplifier constructed in accordance with this invention, the plate supply was 150 volts, the cathode 24 was maintained at about 50 volts above ground, resistances 30 and 34 being about 6,000 ohms and 10,000 ohms, respectively, the biasing potential applied by battery 22 was 3 volts, and that supplied by batteries 55 and 65 to the control grid of tube 18 was about 39 volts, much in excess of the 7 or 8 volts required for cut-off in a tube of this type. Resistances 71 and 73 were of the order of .5 megohm and 100,000 ohms, respectively.

Although this invention has been described with reference to a single embodiment, it is not limited in scope thereto but by the appended claims only.

What is claimed is:

1. In combination, an amplifier, an input circuit and an output circuit therefor, said amplifier comprising an amplifying electron discharge device having a control grid, a cathode and an anode, and a volume control circuit connected between said output and input circuits and including a control electron discharge device having a control grid, a cathode and an anode, said control device's grid being biased to a negative potential much greater than required for anode current cut-off, its cathode being at a lower potential relative to ground than the cathode of said amplifying device, and its anode being connected to the grid circuit of said amplifying device, and means to prevent the amplifying device's grid from going positive when the control device's anode is at a higher potential than said amplifying device's cathode, said means being included in said amplifying device.

2. In combination, an amplifier, an input circuit and an output circuit therefor, said amplifier comprising an amplifying electron discharge device having a control grid, a cathode and an anode, and a volume control circuit connected between said output and input circuits and including a control electron discharge device having a control grid, a cathode and an anode, said control device's grid being biased to a negative potential much greater than required for anode current cut-off, its cathode being at a lower potential relative to ground than the cathode of said amplifying device, and its anode being connected to the grid circuit of said amplifying device, and means to prevent the amplifying device's grid from going positive when the control device's anode is at a higher potential than said amplifying device's cathode, said means comprising a diode, the anode of which is connected to that of said control device.

3. In combination, a three-stage amplifier and a volume control circuit therefor, the first stage of said amplifier comprising an amplifying-rectifying electron discharge device and the succeeding stages amplifying electron discharge devices, each device comprising a control grid, a cathode and an anode, and said control circuit including a control tube having a control grid, a cathode and an anode, means for applying an initial bias on the control grid of the first device, a cathode resistor in the second device for applying a bias to its control grid, and means for applying an initial bias to the control grid of the third device and to that of the control tube, a negative feedback connection from the output of the third device to the cathode end of the cathode resistor of the second device, a connection from the control tube anode to the grid circuit of the first device and to the rectifying anode of said first device, said connection causing change of the first device's control grid potential when the control tube anode is at a potential less than a pre-assigned value and preventing said control grid from going positive when the control tube anode potential exceeds such value.

JAMES O. EDSON.