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AUTOMATIC VOLUME CONTROL CIRCUITS

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Fig. 1

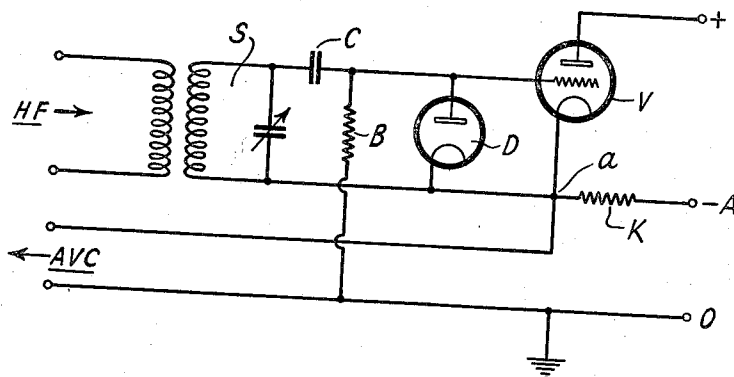
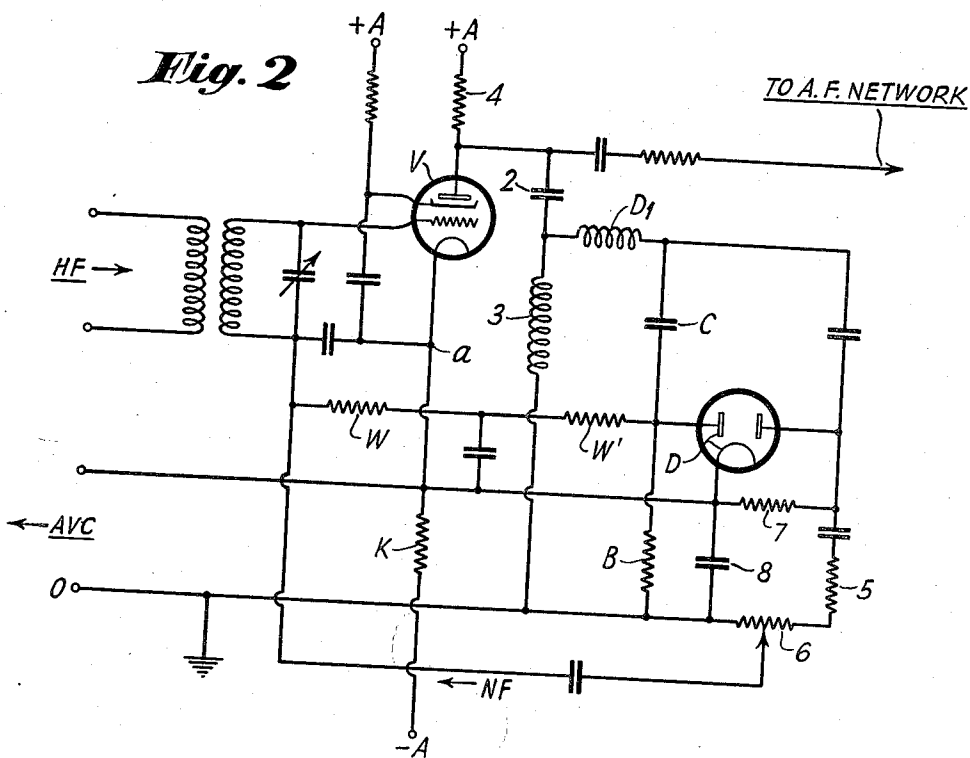


Fig. 2



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AUTOMATIC VOLUME CONTROL CIRCUITS

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This invention is concerned with a circuit organization designed to amplify the automatic volume control potential in receiver sets.

The object of such amplification is to raise the effects of volume control also in small receiver sets, say sets comprising only one radio frequency stage, to such an extent that it will satisfy all requirements. It is known in the prior art to amplify the volume control potential in a distinct tube, or else in a tube which also serves to amplify an alternating potential used in the operation of the receiver apparatus. The practicing of such amplification of direct current potential is attended with serious difficulties for the reason that fluctuations in working potential (supplied from battery or mains) occasion undesirable shifts in the control potential, with the result that the tube to be subjected to control action, for instance, may be shifted into the region of grid current flow. Moreover the amplifying tube can not be replaced by a new tube without an incidental adjustment of the working voltages because of variations or fluctuations of manufacturing constants.

Now, the present invention is concerned with an improved type of volume-control (AVC) circuit in which the amplification of the control potential obtained by a rectification of the radio frequency energy is effected in a tube, with the amplified control voltage being taken off at the cathode end of a resistance contained in the cathode circuit.

The invention more particularly resides in the feature that the diode serving to provide the control potential (AVC potential) is connected directly, or else through de-coupling resistances, between grid and filament of the amplifier tube adapted to amplify the control potential, while the load resistance of the diode, which at the same time serves to impress the grid biasing potential upon the amplifier tube, has its end away from the grid, connected with a fixed potential of the receiver apparatus, more particularly a reference line rather than with the cathode of the amplifier tube.

The invention shall now be described in more detail by reference to the drawing wherein Figs. 1 and 2 show different embodiments. In the exemplified embodiment in Fig. 1, the radio frequency energy (HF) is fed to the oscillation circuit S, and thence through the condenser C to the diode D which comprises the load resistance B. The rectified potential serves to control the amplifier tube V, the amplified control potential being made available across the cathode resist-

ance K thereof. In other words, the cathode of tube V experiences changes of its potential in relation to $-A$, and thus, also, in reference to the reference line O to a more marked degree than the anode of tube D in reference to point a . The amplified control potential is then impressed upon the tube to be submitted to control action through the AVC conductors.

Now, the operation of this circuit organization is as follows: First the circuit elements S, C and D are assumed to be absent, that is, no radio frequency energy is fed in. The remaining circuit elements constitute a markedly stabilized direct current amplifier. A high degree of stabilizing action is secured by the cathode resistance K, the latter being suitably chosen high, and, also, the potential across O and $-A$ should be chosen correspondingly high. This stabilization is necessary in order that by such fluctuations in the main supply voltage as may happen, no shift in the potential of the cathode of tube V, and thus of the steady biasing voltage of the tube to be regulated, may occur.

The stabilization operates in the following manner: If, for instance, the plate potential, and thus the plate current, of tube V rise as a result of a fluctuation in the operating potential, the result is an increase of potential at K. The potential prevailing at the lower end of K in reference to a acts through $-A$, O, and B upon the grid, and since it represents a higher negative biasing potential it reduces again the plate current. If, on the contrary, the potential O in reference to $-A$ experienced an increase, then the negative biasing potential prevailing across K would be diminished since both potentials are in series opposition. As a result the negative biasing potential of tube V is reduced. The plate current rises, and this occasions a higher voltage at K so that the negative biasing potential is caused to rise again approximately to the original value. Since the biasing potential acting across the bottom end of B and the cathode of tube V acts not only as a biasing voltage for tube V, but through the AVC leads acts also upon the tube to be controlled, also the biasing voltage of the latter is rendered unaffected by such fluctuations as may happen in the supply-line voltage, and these would become extremely annoying in the absence of the cathode resistance K.

Assuming parts S, C, and D to be existing, it will first be noticed that on the anode of the diode D there prevails the same negative biasing potential acting as a retarding, or delay, voltage for the volume-control as the voltage im-

pressed upon the grid of tube V and acting between the AVC conductors. This biasing voltage is equal to the difference between the potential across the resistance K and the voltage applied across O and -A, and is obtained by choosing suitable values for the resistance K.

If an impressed radio frequency potential surpasses the delay potential, rectification is had and the anode of D becomes more negative. If, then, the cathode of the diode D were connected with the lower end of the load resistance B rather than with the cathode point *a* of tube V, as is usually the case, the direct voltage furnished from the rectifier and its effect upon the amplifier tube V would be compensated again, in the very same manner as if the voltage of point O relative to -A had been altered. However, according to the invention the cathode of the diode D and the bottom end of resistance B, as shown in Fig. 1, are connected to different points. The practical result is that the stabilization of the amplifier stage is left unaffected, while yet amplification of the control voltage is brought about. In other words, a counter, or inverse, regulator or control action is produced for fluctuations of the operating voltage, whereas for the volume-control potential which is to be amplified, there occurs no inverse, or counter, control action, but merely the normal amplification. The underlying reason is this: When the rectified, negative voltage impressed upon the grid of tube V decreases the plate current of tube V, the voltage across K drops, and, as a consequence, there occurs a decrease of the potential acting on the cathode of tube V and thus, also, on the cathode of diode D into the negative region.

As a result, the voltage across the cathode of tube D and the bottom terminal of resistance B having a negative action for the anode of the diode is reduced, while, as a consequence, the diode current is raised. The increase in the diode current, however, results in a higher potential across the resistance B, and this, in turn, causes the anode of the diode to be subjected to a more negative biasing potential. The counter-action due to the decrease of the potential at the cathode of tube V, as will thus be seen, is again compensated and cancelled out almost completely by the resulting stronger diode current. One could also conceive of this process in a way as if the potential of the grid of V is forced to fall in step (is entrained or driven) by the diode current of D upon the occurrence of variations of potential of *a*.

Fig. 2 illustrates an exemplified embodiment of this circuit in which the tube V, in a reflex circuit scheme, for amplification of both radio and audio energies, is further relied upon to amplify the volume-control voltage. The incoming radio frequency energy HF is subjected to aperiodic amplification in tube V and is rectified in the right-hand diode to result in audio voltage being fed back to the tube V and being taken off at the anode in amplified form, and then fed forward to the audio power stage. In the left-hand diode D is produced the control potential which is impressed through two filter resistances W upon the grid of the tube V. The amplified control potential arises across the cathode resistance K, and is thence impressed upon the RF tube to be controlled. The choke-coil D₁ serves to correct the irregularities due to decrease in the gain at the higher frequencies (about 1000 kc.) in that it forms a condition of resonance together with the diode capacity. The coupling capacity

2 of 50 mmf. (micromicrofarads) together with the choke 3 of 100 mh. precludes audio energy from the diode.

In measurements made with this circuit, the voltage of the cathode of tube V in reference to the reference lead O which is equal to the grid biasing voltage of tube V, was found to experience a shift of only ± 0.35 v., in the presence of a $\pm 10\%$ variation of all operating potentials. Taking into consideration all possible tube tolerances, aging of tubes and a $\pm 10\%$ supply-line voltage variation, the maximum departures from the normal or rated grid biasing voltage was found to be -0.5 to $+0.8$ v. by actual measurement.

Insofar as the control action is concerned, the following situation was found: In the presence of a 1:3 transformation of the antenna potential at the oscillation circuit of the only tube to be controlled, and a gain in this tube of 330 maximum, the control curves evidenced a nearly ideal shape, for the point of incipient control and simultaneously the full-load operation of the power stage were around 100 microvolt input potential. From this point up to 100 millivolt (equal to a ratio of 1:1000) the output voltage was found to vary only as 1:2. When the controlled tube was of the hexode type, practically no overload limit was found to exist, whereas with a pentode the overload limit lay around 150 millivolts.

The bottom end of resistor K is suitably impressed with a voltage that is markedly negative in reference to the reference line of the receiver, say, -100 v. Such a high voltage, for instance, will be present when the field coil of the loudspeaker is used as a choke. It will be noted that the following constants for the circuit of Fig. 2 are given merely for illustration:

W=	1 M-ohms
W'=	0.5 M-ohms
Resistor 4=	15 K-ohms
Resistor 5=	200 K-ohms
Resistor 6=	2 M-ohms
Resistor 7=	100 K-ohms
B=	200 K-ohms
K=	1600-1700 ohms
Condenser 8=	6 mf.
D ₁ =	1 mh.

What is claimed is:

1. In combination with a signal amplifier of the type having a tube provided with a least a cathode, grid and anode, a signal input circuit connected between the grid and cathode, a resistive impedance in the space current path of said tube and connected between the cathode and a point of negative potential, a second resistive impedance connected between the grid and a potential point which is positive with respect to said negative point, said first impedance having a sufficiently large value to cause the cathode to be positive with respect to said grid, and a rectifier connected in circuit with said second impedance whereby the direct current voltage developed across the latter by rectified signals is impressed on said grid for direct current amplification, a second rectifier, means for impressing amplified signals in the amplifier anode circuit upon the second rectifier, means impressing the audio voltage output of the second rectifier upon the amplifier tube grid whereby said amplifier acts as an audio amplifier.

2. In combination with a signal amplifier tube having at least a cathode, a signal grid and an

output plate, means responsive to space current amplitude of the tube for establishing the cathode at a positive potential with respect to a fixed potential point, a resistor connecting the grid to said fixed point to establish the grid at a negative bias, a signal rectifier circuit comprising a diode including said resistor in circuit therewith as the load impedance, direct current voltage variations developed across said resistor due to signal rectification being amplified by said tube, and means for deriving amplified direct current voltage variations from said responsive means.

3. In combination with a signal amplifier tube having at least a cathode, a signal grid and an output plate, means responsive to space current amplitude of the tube for establishing the cathode at a positive potential with respect to a fixed potential point, a resistor connecting the grid to said fixed point to establish the grid at a negative bias, a signal rectifier circuit comprising a diode including said resistor in circuit therewith as the load impedance, direct current voltage variations developed across said resistor due to signal rectification being amplified by said tube, and means for deriving amplified direct current voltage variations from said responsive means, said diode having its electrodes connected to said

responsive means so that the diode is normally non-conductive.

4. In combination with a tube, means to impress radio energy thereon for amplification, rectifier means to derive an audio voltage from the amplified energy, means to impress the audio voltage on the tube for audio voltage amplification, a second, separate rectifier means deriving a direct current voltage from the amplified radio energy, means impressing the direct current voltage upon said tube for direct current voltage amplification, and means for utilizing the amplified direct current voltage.

5. In combination with a tube, means to impress radio energy thereon for amplification, rectifier means to derive an audio voltage from the amplified energy, means to impress the audio voltage on the tube for audio voltage amplification, a second, separate rectifier means deriving a direct current voltage from the amplified radio energy, means impressing the direct current voltage upon said tube for direct current voltage amplification, means for utilizing the amplified direct current voltage, and means for utilizing the amplified audio voltage.

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