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RADIO VOLUME CONTROL

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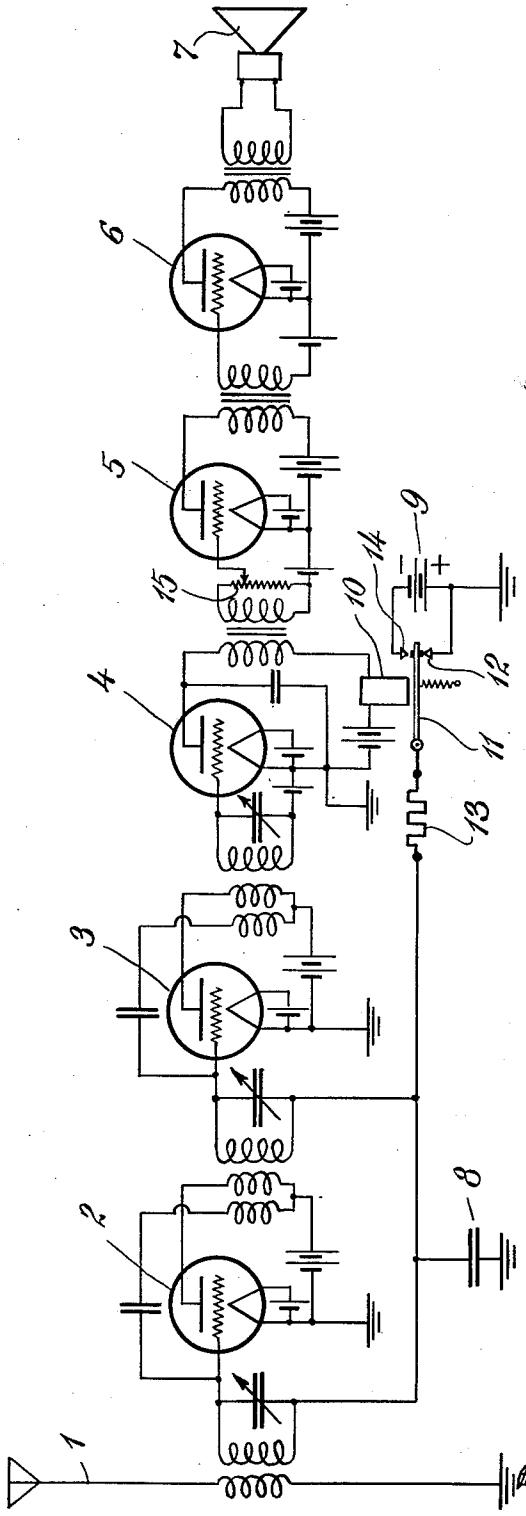

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RADIO VOLUME CONTROL

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This invention relates to radio receiving systems—especially broadcast receivers—and has for its object to provide simple and effective means for securing and maintaining substantially constant output volume—that is to say, substantially uniform signal loudness irrespective of variations in the strength of incoming signals. The underlying purpose is to enable the production of broadcasting receivers through which all stations are received with equal loud speaker volume without the necessity of regulating the manual volume control each time a different station is tuned in, and, further, to offset the effect of fading signals.

From a practical standpoint, the object, as stated above, is not literally and wholly attainable by the present invention because it is not practicable, even if possible, to amplify exceedingly weak signals sufficiently to produce good loud speaker volume—the reason being that extraneous disturbances are equally amplified and the result is altogether unsatisfactory. But within reasonable limits of incoming signal strength the invention herein described will produce substantially uniform output volume. This does not necessarily imply an exceedingly close approximation to uniformity as determined by laboratory methods, but does imply substantial uniformity as determined by the ear of the ordinary listener. It requires quite a large actual increase or decrease of output energy to make a noticeable difference in the apparent impression upon the ear.

The desired result is accomplished by automatically regulating the high-frequency amplification of incoming signals so that the signal strength at the output end of the high-frequency amplifier is substantially the same whether the incoming signal wave is weak or strong. The regulation is effected by means of a variable grid-potential bias on the high-frequency amplifier tubes—the grids being rendered highly negative in response to a strong incoming signal wave and less negative, or of zero potential in response to weaker incoming waves.

It is, of course, well known that the degree of amplification in a high-frequency amplifier is susceptible of control through variation of the grid potential bias. This may also be done by varying the filament temperature or plate voltage. But to accomplish this result automatically and smoothly, without any appreciable accompanying disturbance in the nature of noise production, is another matter. That is the problem to which the present invention is directed.

The accompanying drawing shows, by way of example, a schematic circuit diagram of a five tube broadcast receiver including an arrangement in accordance with a preferred form of the invention.

The circuit illustrated comprises a receiving antenna 1, two stages of radio-frequency amplification in cascade including, respectively, three-electrode vacuum tubes 2 and 3, a detector stage including a three-electrode detector tube 4, two stages of audio-frequency amplification including, respectively, three-electrode vacuum tubes 5 and 6, and a loud speaker 7.

It is apparent from the drawing that the stages are transformer coupled throughout and that the two radio-frequency stages are tuned, and neutralized in accordance with the well known Hazeltine method of capacity coupling neutralization.

As a fundamental feature, the invention contemplates the use of an electrostatic condenser 8 preferably of substantial capacity, for example, one microfarad, connected, as will be seen, between grid and filament of one or more of the radio-frequency amplifier tubes. As shown in this particular instance, the condenser 8 is connected through ground between grid and filament of both tubes 2 and 3, but it will be apparent as the description progresses that this condenser is not necessarily connected with more than one of the radio-frequency amplifier tubes.

The function of the condenser 8 is to provide an automatically variable potential bias on the grids of tubes 2 and 3. The purpose is to impress upon these grids an increasingly negative bias in response to increasingly strong incoming signals and, vice versa, a decreasingly negative bias in response to increasingly weak signals. The condenser 8

is arranged to be charged by a suitable source of current, such as a battery 9, and the operation of charging and discharging the condenser is under the control of a relay 10 whose winding is included in the plate circuit of the detector 4. The relay 10 is preferably of the galvanometer type and has an armature 11 which normally rests on its back contact 12 in which position it closes a circuit to ground from one terminal of the condenser 8 and from the grids of the tubes 2 and 3. With the contact 12 closed the condenser 8 obviously cannot retain any charge. A high resistance element 13 having a resistance value of, say one megohm, is included in the conductor between the armature 11 and the condenser 8. The function of this resistance is to check the flow of current from the battery 9 to the condenser 8 so that the latter will not charge and discharge suddenly but rather slowly. This prevents any large sudden change of potential on the grids of the tubes 2 and 3 and thereby prevents any noticeable click in the loud speaker 7 when the contacts 12 and 14 are opened and closed.

Assuming that the incoming signal wave being received is very weak, the armature 11 will remain in its back position, as shown, and the grids of the tubes 2 and 3 will be at earth direct current potential—the condenser 8 being uncharged. This is the usual condition for maximum amplification. Very weak signals will be amplified to the full extent of the ability of the high-frequency amplifier; but since, as assumed, the signals were very weak to begin with the current increase in the plate circuit of the detector 4 will not be enough to energize the relay 10 sufficiently to break contact 12.

Now, suppose that the incoming signal wave becomes considerably stronger either by reason of tuning to another station, or some other cause. It will be amplified as before and, assuming that it reaches a predetermined signal strength level, it will effect a sufficient increase in the detector plate current flowing through the winding of relay 10 to cause the relay to open contact 12 and close contact 14. This connects the negative terminal of the battery 9 to the grids of the tubes 2 and 3 through the high resistance 13 and also connects the battery 9 in circuit with the condenser 8 through the same resistance. The resistance 13 being of high value will permit current from the battery 9 to flow through it at a very low rate, and the condenser 8 being of relatively large capacity will charge up rather slowly. Thus, it will be seen, the grids of tubes 2 and 3 do not immediately assume the potential of the negative terminal of battery 9 but, on the contrary, these potentials are built up rather gradually as the condenser 8 becomes charged. Of course the lag in the change of grid potential is not of long duration according to the ordinary conception of time, but by comparison with the spontaneous change of grid potential which would be effected if it were not for the condenser 8 and resistance 13 the lag is of very considerable duration.

With the contact 14 held closed, the grids of tubes 2 and 3 become more and more negative thereby decreasing the amplification of the incoming signal wave until the current flowing through the winding of relay 10 is no longer sufficient to hold the armature 11 in its fully actuated position. The armature then drops back sufficiently to open contact 14 but not sufficiently to close contact 12 unless it happens that the incoming signal wave becomes substantially weaker—in which event contact 12 would be closed. With contacts 12 and 14 both open and the incoming signal strength remaining constant the condenser 8 will maintain the grids of tubes 2 and 3 at the proper negative potential, except for such change as may occur due to leakage discharge from the condenser. If the incoming signals should then become substantially weaker the armature 11 would drop back and close contact 12. With contact 12 closed condenser 8 discharges slowly through resistance 13 to ground, and the grids of tubes 2 and 3 become gradually less negative as the condenser discharges. The amplification then rises proportionately to the decrease of grid-bias potential and, assuming that the strength of the incoming signal wave does not again decrease, the relay 10 will become energized and actuate its armature as before—both contacts being held open. If, subsequently, the strength of the incoming signal rises materially, the armature 11 will close contact 14 and the condenser 8 will again take charging current from battery 9, and the negative potential on the grids of tubes 2 and 3 will rise accordingly. On the other hand, if the incoming signal becomes weaker, the relay will become further deactuated closing contact 12.

It will be apparent that whenever the magnitude of the incoming signal wave is below a certain predetermined value the contact 12 will remain closed and the grid potential on tubes 2 and 3 will be zero, that is, earth potential. Also it will be apparent that if the strength of the amplified signal wave reaches a certain predetermined upper value the contact 14 will close and the amplification will be cut down. The contact 14 never remains closed, however, but always opens as soon as the negative grid bias has been built up sufficiently to prevent over-amplification. Assuming an incoming signal wave of fairly constant magnitude but sufficiently strong to initially open contact 12, the armature 11 will either immediately assume a position wherein contacts 12 and 14 are both open or it will first close contact 14 and then drop back to the intermediate position and will

hold that position providing there is not any leakage discharge from condenser 8. If there is such a leakage discharge it will cause a gradual dropping off of the negative grid bias and this will result in the contact 14 being closed momentarily from time to time sufficiently to maintain the charge on condenser 8 at a proper value proportional to the magnitude of the incoming wave. It is evident that with very strong incoming signals a large negative bias will be built up on the amplifier grids because the amplified signal current will be sufficient to hold the relay fully actuated in spite of the reduced effectiveness of the amplifier. However, if the potential of battery 9 is large enough, as it should be, the relay will become deactuated sufficiently to open contact 14 regardless of the strength of the incoming signal. This follows from the fact that the amplification could be reduced to the vanishing point by applying a sufficient negative bias to the grids.

For incoming signal waves stronger than a predetermined minimum value it is manifest that the amplified output will be substantially uniform, the only variation being represented by the difference between the relay energizing current which is just sufficient to break contact 12 and that which is just sufficient to close contact 14. Of course, any large sudden increases or decreases in the strength of incoming signal waves are apt to be momentarily noticeable, but that is not important.

The values which have been given for the capacity of condenser 8, namely, one microfarad, and the resistance of the resistance element 13, namely, one megohm, have been found by trial to be satisfactory but not critical. By increasing the capacity of condenser 8 or the resistance of the resistance element 13, or both of them, the time lag may obviously be increased, and vice versa. It is preferable that the time lag be short enough so that there is no perceptible fluctuation in the output volume, yet long enough to preclude any perceptible disturbance resulting from sudden changes of grid-bias potential.

The total result of the arrangement described is that weak signals are greatly amplified and very strong signals are but slightly amplified, while signals of intermediate strength are amplified proportionately. This does not necessarily mean absolutely constant output volume, but with careful design of the apparatus a very close and altogether sufficient approach to that ideal may be realized.

The condenser 8, in addition to functioning as above described, provides a low-impedance path between grid and filament of each of the tubes 2 and 3, thereby completing the input circuits of those tubes.

In the circuit illustrated provision is made for manually controlling the output volume independently of the automatic control. This provision comprises a potentiometer 15 in the input circuit of the first audio amplifier tube 5—the movable contact being connected to the grid. This represents one of the commonly employed methods of volume control. It will be apparent that there are other practical ways in which manual volume control can be effected.

In the circuit illustrated the arrangement is such that the grid-bias potential fluctuates between zero or earth potential and some predetermined maximum negative value, but it will be obvious that the arrangement could be readily modified to provide a minimum bias more negative than zero or even a positive bias. Furthermore, the invention may in like manner readily be applied to vacuum tubes of more than three electrodes. It is likewise obvious that other modifications and deviations from the arrangement shown can be made without departing from the spirit of the inventive idea.

I claim:

1. A signal-current amplifying and rectifying system including, in combination: an amplifying vacuum tube having a grid whose negative potential limits the degree of amplification, a plate which carries amplified signal current and a filament system; a rectifying vacuum tube having a grid circuit coupled to said plate, and a plate circuit in which flows a uni-directional rectified signal current which varies with said amplified signal current; a two-way relay having a coil connected in said plate circuit, and two contacts, the first of which remains closed only when said amplified signal current remains less than a certain value, and the second of which closes only when said amplified signal current exceeds said certain value; a condenser having one terminal connected to said filament system and another terminal connected to said grid and connectable alternately to a condenser discharging circuit and to a condenser charging circuit, said condenser discharging circuit including said first contact and a high resistance in series, and said condenser charging circuit including said second contact, a high resistance and a negative-potential source in series, whereby the average intensity of said amplified signal current is maintained at said certain value, substantially independently of large variations in signal intensity.

2. A modulated-carrier-current amplifying and rectifying system including, in combination: an amplifying vacuum tube having a grid whose negative potential limits the degree of amplification, a plate which carries amplified carrier current and a filament system; a rectifying vacuum tube having a grid circuit coupled to said plate, and a plate circuit in which flows a uni-directional rectified car-

rier current which varies with said amplified carrier current; a two-way relay having a coil connected in said plate circuit, and two contacts, the first of which remains closed only when said amplified carrier current remains less than a certain value, and the second of which closes only when said amplified carrier current exceeds said certain value; a condenser having one terminal connected to said filament system and another terminal connected to said grid and connectable alternately to a condenser discharging circuit and to a condenser charging circuit, said condenser discharging circuit including said first contact and a high resistance in series, and said condenser charging circuit including said second contact, a high resistance and a negative-potential source in series, whereby the average intensity of said amplified carrier current is maintained at said certain value, substantially independently of large variations in signal intensity and of the degree of modulation.

3. A signal-current responsive system including in combination, a vacuum tube having a filament system, a control electrode whose bias potential limits the responsiveness of said tube, and an output circuit, a condenser connected between said electrode and said filament system, a relay having a closable contact, means for charging said condenser when said contact is closed including in series with said condenser, said contact, a high resistance and a source of bias potential, and means coupling said output circuit to said relay and closing said contact when the current in said output circuit approaches an upper limiting value, whereby the current in said output circuit is prevented from exceeding said value.

4. A modulated-carrier-current responsive system including in combination, a vacuum tube having a filament system, a control electrode whose bias potential limits the responsiveness of said tube, and an output circuit, a condenser connected between said electrode and said filament system, a relay having a closable contact, means for charging said condenser when said contact is closed including in series with said condenser a high resistance and a source of bias potential, and means coupling said output circuit to said relay and closing said contact when the carrier current in said output circuit approaches an upper limiting value, whereby the carrier current in said output circuit is prevented from exceeding said value, independently of the degree of modulation.

5. A signal-current amplifying system including in combination, an amplifying vacuum tube having a filament system, a control electrode whose bias potential limits the amplification of said tube, and an output circuit, a condenser connected between said electrode and said filament system, and a relay having a closable contact, means for charging said condenser when said contact is closed including in series with said condenser said contact, a high resistance and a source of bias potential, and means coupling said output circuit to said relay and closing said contact when the amplified current in said output circuit approaches an upper limiting value, whereby the current in said output circuit is prevented from exceeding said value.

6. A modulated-carrier-current amplifying system including in combination, an amplifying vacuum tube having a filament system, a control electrode whose bias potential limits the amplification of said tube, and an output circuit, a condenser connected between said electrode and said filament system, a relay having a closable contact, means for charging said condenser when said contact is closed including in series with said condenser, said contact, a high resistance and a source of bias potential, and means coupling said output circuit to said relay and closing said contact when the amplified carrier current in said output circuit approaches an upper limiting value, whereby the current in said output circuit is prevented from exceeding said value, independently of the degree of modulation.

7. A signal-current amplifying and rectifying system including in combination, an amplifying vacuum tube having a filament system, a control electrode whose bias potential limits the amplification of said tube, and an output circuit carrying amplified signal current, a rectifying vacuum tube having an input circuit coupled to said output circuit, and an output circuit carrying uni-directional rectified signal current, a condenser connected between said electrode and said filament system, a relay carrying said rectifying current and having a closable contact which is closed in response to said rectified current when said amplified signal current approaches an upper limiting value, and means for charging said condenser when said contact is closed including in series with said condenser, said contact, a high resistance and a source of bias potential, whereby said amplified signal current is prevented from exceeding said value.

8. A modulated-carrier-current amplifying and rectifying system including in combination, an amplifying vacuum tube having a filament system, a control electrode whose bias potential limits the amplification of said tube, and an output circuit carrying amplified modulated carrier current, a rectifying vacuum tube having an input circuit coupled to said output circuit and an output circuit carrying uni-directional rectified current which varies with the carrier component of said amplified current, a condenser connected between said electrode and said filament system, a relay carrying said rectified current

and having a closable contact which is closed in response to said rectified current when said carrier component approaches an upper limiting value, and means for charging said condenser when said contact is closed including in series with said condenser, said contact, a high resistance and a source of bias potential, whereby said carrier component is prevented from exceeding said value.

9. A modulated-carrier-current amplifying and rectifying and modulation-frequency-output-current amplifying system having uni-directional and modulation-frequency output currents, including in combination, an amplifying vacuum tube having a filament system, a control electrode whose bias potential limits the amplification of said tube, and an output circuit which carries amplified modulated carrier current, a rectifying vacuum tube having an input circuit coupled to said output circuit, and an output circuit in which flows said uni-directional output current which varies with the carrier component of said amplified current, a relay having a coil connected in said output circuit of said rectifying tube, and having a closable contact which closes only when said carrier component approaches an upper limiting value, means for charging said condenser when said contact is closed including in series with said condenser, said contact, a high resistance and a source of bias potential, whereby said carrier component is prevented from exceeding said value, independently of the degree of modulation, and an amplifier operated by modulation-frequency output current from said rectifying vacuum tube, and having means for manually adjusting the amplification therein whereby the output of said system can be varied at will, notwithstanding that the input to said modulation-frequency amplifier is maintained substantially invariable.

In testimony whereof I affix my signature.

HAROLD A. WHEELER.