

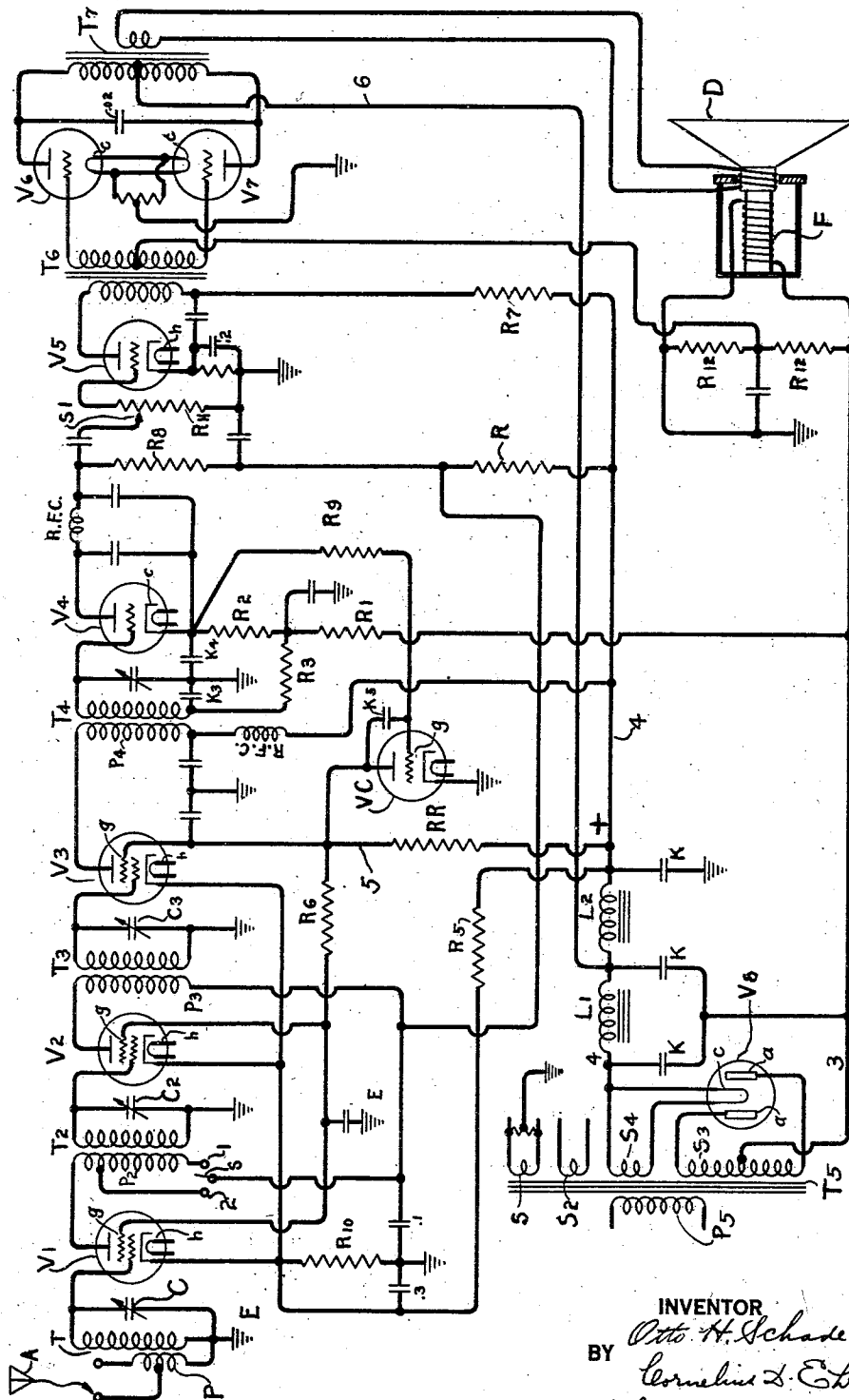
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O. H. SCHADE

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AUTOMATIC VOLUME CONTROL

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INVENTOR
Otto H. Schade
 BY *Cornelius L. Ehret*
 his ATTORNEY

UNITED STATES PATENT OFFICE

OTTO H. SCHADE, OF PHILADELPHIA, PENNSYLVANIA, ASSIGNOR TO ATWATER KENT MANUFACTURING COMPANY, OF PHILADELPHIA, PENNSYLVANIA, A CORPORATION OF PENNSYLVANIA

AUTOMATIC VOLUME CONTROL

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My invention relates to the control of thermionic amplifiers, particularly as utilized in radio receiving apparatus, to effect or maintain desired intensity or amplitude of signals or speech.

In accordance with my invention, carrier wave energy, for example, that in excess of a predetermined magnitude, produces an effect reducing amplification, and the effect, independently of the carrier energy, further reduces amplification; more specifically, in an amplifier employing one or more screen-grid tubes, the screen grid potential is reduced in response to unduly high amplitude of carrier wave energy, and the resulting decrease of amplifier anode current utilized further to reduce the screen-grid potential.

My invention further resides in the method and system hereinafter described and claimed.

For an understanding of one of the forms my invention may take, reference is to be had to the accompanying drawing, in which there is diagrammatically represented radio receiving apparatus utilizing screen grid amplifier tubes. The particular system shown has three stages of radio frequency amplification using the screen grid tubes V1, V2 and V3, a detector V4, and two stages of audio frequency amplification, the first of which includes the three element tube V5, the last stage employing two tubes V6 and V7 connected in push pull arrangement.

The tubes V1, V2, V3 and V4 are coupled respectively by the transformers T2, T3 and T4 across whose secondaries are connected the condensers C2, C3 and C4. The input circuit of the first tube V1 is coupled to the antenna circuit between the aerial A and earth E by transformer T whose primary P is tapped to permit the use of antenna of different dimensions without effect upon the setting of the condenser C connected across the secondary of transformer T. To minimize the antenna capacity transferred to the first tuned circuit, the transformer T is of high step-up ratio of voltage transformation. The rotors of all of the tuning con-

densers are or may be mechanically connected for movement in unison.

The primaries P3 and P4 of the transformers T3, T4 have approximately the same number of turns as the respective secondary windings. Similarly the transformer T2 has substantially 1 to 1 ratio of primary to secondary turns when the contact member of switch *s* engages the coil terminal 1 to include all of the primary P2 in circuit. When the switch contact is moved to the left to engage the contact 2, only a relatively few number of turns of the primary are included in circuit which results in decreased transfer of energy to the input circuit of V2.

The output circuit of the detector tube V4 and the input circuit of the audio amplifier tube V5 may be coupled in any suitable manner. In the system shown, there are utilized the resistances R8, R11 of suitable value, for example 100,000 ohms, whose respective plate and grid terminals are connected by the usual coupling condenser, unlettered.

The secondary S of the power supply transformer T5 whose primary P5 is connected to any suitable source of alternating current, as conductor supplying 60 cycle circuit at 110 volts, supplies current to the heaters *h* of the tubes V1, V2, V3, V4 and V5. The secondary S2 of the transformer T5 furnishes current to the cathodes *c* of the audio amplifier tubes V6 and V7.

The anodes *a, a* of the power rectifier tube V8 are connected to the terminals of the secondary S3 of the power transformer. The negative conductor 3 is connected to a midpoint of the secondary S3 and the high potential positive conductor 4 is connected to cathode *c* of the rectifier tube V8 which is heated by current supplied from the secondary S4 of transformer T5. The inductances L1, L2, whose resistances may be respectively 200 and 2000 ohms, in the positive conductor 4, and the field winding F with the dynamic speaker D in the negative conductor 3, together with condensers K, K, K, comprise a filter for smoothing the pulsations of the rectified current as described and claimed in copending Silva application, Serial No. 361,910, filed May 10, 1929.

The screen grids g of tubes V1, V2 and V3 are connected by conductor 5 to the lower potential terminal of inductance L2 through a resistance RR of suitably high value, for example 100,000 ohms. A radio frequency filter resistance R6 of lower value, for example 10,000 ohms, is connected between conductor 5 and the screen grids g of tubes V1, V2. A radio frequency by-pass condenser of suitable value, for example 0.1 mfd is connected between the screen grids and earth E.

The anodes of the screen grid tubes V1, V2, and the detector tube V4 are connected to the positive conductor 4 of the high potential supply through a coupling resistance R at suitable value, for example 4,000 ohms. The anode of the screen grid amplifier tube V3 is connected to the positive conductor of the B power supply through the radio frequency choke coil RFC, and the anode of the first audio amplifier V5 is connected to the same through an audio filter resistance R7 of suitable value.

To attain high voltage on the anodes of the tubes V6 and V7 the anode conductor 6 from the midpoint of the output transformer T7 is connected to the conductor 4 between the impedances L1, L2 of the filter. The grid bias potential of the tubes V6 and V7 is obtained by connecting the midpoint of the secondary of the input transformer T6 to a suitable point on the resistance R12 connected across the field winding F of the dynamic speaker D. Between this point and ground there is included a by-pass condenser of suitable value.

The biasing potential for the control grids of the radio frequency amplifier tubes V1, V2 and V3 is obtained by connecting the uni-potential cathodes of the tubes to a suitable point in a potentiometer circuit consisting of the resistances R10, R5, connected between the positive conductor 4 and earth E. The values of these resistances may be respectively 400 and 12,000 ohms. In the system thus far described, the only control over intensity of signals is the large step of amplification change effected by movement of the contact s into engagement with either of contacts 1 or 2. The remaining description is chiefly concerned with automatic control of volume to effect or maintain a desired intensity of signals reproduced by the speaker D.

The uni-potential cathode c of the detector V4 is connected to conductor 3 of the power supply through resistances R1, R2 of suitable value, for example 150,000 and 65,000 ohms respectively, and to the grid g of the control tube VC through an audio frequency filter resistance R9 of suitable value as for example 150,000 ohms. The input circuit of the detector tube is connected to the terminal of resistance R2 remote from the cathode c thereof to derive grid biasing potential from the detector anode current. The connection in-

cludes an audio frequency filter resistance R3 of suitably high value as for example 1.5 megohms. The lower terminal of the secondary of transformer T4 and the terminal of resistance R3 are connected to ground E by condenser K3 of suitably high magnitude as 0.1 microfarad. The other terminal of resistance R3 is connected to earth through a similar condenser as indicated.

Between the control grid and uni-potential cathode of the control tube VC there are two sources of potential in series and in opposition, one of which derived from the field winding F of speaker D is of constant value, and the other of which derived from the flow of current in the anode circuit of the detector tube varies in accordance with the magnitude of the amplified carrier wave energy impressed upon the input circuit of the tube.

The relation between these two opposing potentials is such that for all magnitudes of carrier energy below a certain value, there is no plate current through the control tube VC. The increased plate current of the detector results in a slightly lower potential of the detector anode.

With a carrier of intensity giving normal volume of reproduction, the detector plate voltage attains a still lower value because of increased IR drop in the plate circuit. For this amplitude of reproduction, the resultant of the opposing potentials effective to bias the grid of the control tube is of a magnitude and sign which permits slight flow of current in the plate circuit of the control tube.

When the carrier amplitude is in excess of this value, the anode current of the detector tube increases to such extent that the negative bias of grid g of the control tube is sufficiently decreased to permit more or less substantial flow of anode current through the control tube. This results in a greater IR drop through the resistance RR with resulting decrease of the voltage applied to the screen grids of tubes V1, V2 and V3. This reduces the amplifying power of the tube and consequently the amplitude of energy impressed upon the input circuit of the detector. Further, the decreased screen grid voltage results in decreased anode current which reduces the IR drop through resistance R thereby increasing the anode voltage of the detector tube V4. The resulting increased current in the anode circuit of the detector tube effects further change in the potential of the grid of the control tube, the cycle repeating until a balance is effected at which the reproduced volume of signals is but slightly more than normal. The composite regulation effected may approach 100% for amplitudes of carrier energy which ordinarily would result in the reproduction of signals above the normal value. Briefly

whereas no regulation is effected with weak signals, for strong signals the adjustments can be made to obtain regulation in excess of 100% so that actually signals from a distant station may be received with greater intensity than those from a local station, but this is an unstable condition and ordinarily not used. In all cases however it will be understood that the reproduced signal intensity does not preferably depart substantially from normal.

The steepness of the regulation curve is varied by changing values of the resistances R, R8, and (R1, R2) and the impedance of the detector tube which is varied by R2 and also by the signal. The values of these resistances are interdependent variables and their improper selection may result in an unstable and generally unsatisfactory condition of operation.

The condenser K5 connected between the grid and anode of the control tube contributes to the prevention of modulation of the screen grid voltage, as well as feed-back, at audio frequency.

To receive local or strong signals, it is preferable that the switch *s* be in engagement with contact 2 to include a smaller number of turns of primary P2 in circuit. Although the volume of signals is the same for either position of the switch, the tubes V1 and V2 are operating under more nearly normal condition of screen grid voltage when transfer of energy from the output circuit of tube V1 is reduced.

To obtain equal volume from carriers which are modulated to different degree, there may be provided a volume control associated with the audio amplifier. For example, the resistance R11 in the input circuit of tube V5 may be provided with a manually adjustable contact or slider *s1*.

What I claim as my invention is:

1. In an amplifier, the method of control which comprises varying a control to change the amplification by and in accordance with the amplitude of carrier wave energy, producing an effect by said control variation, and producing by said effect further and cumulative change of amplification.

2. In an amplifier utilizing one or more thermionic tubes, the method of control which comprises varying the internal tube resistance by and in accordance with the amplitude of carrier wave energy, producing an effect by said variation of resistance, and producing further change of resistance by said effect in the same sense.

3. In an amplifier utilizing screen grid tubes, the method of control which comprises changing the screen grid potential by and in accordance with the amplitude of carrier wave energy, and effecting by the resulting change of anode current further change of screen grid potential in the same sense.

4. In an amplifier utilizing one or more thermionic tubes, the method of control which comprises rectifying amplified carrier wave energy, varying the internal resistance of said amplifier tubes by the rectified energy, producing an effect by said variation of resistance, and producing further change of internal resistance of said amplifier tubes in the same sense by said effect.

5. In an amplifier utilizing one or more thermionic tubes, the method of control which comprises rectifying amplified carrier wave energy, varying the magnitude of an impedance controlling the internal resistance of said tubes in accordance with the magnitude of said rectified energy, and further varying the magnitude of said impedance in the same sense by the change in anode current resulting from the change in internal resistance of said tubes.

6. In a radio system utilizing one or more amplifier tubes, a demodulator tube, and a control tube, the method of control which comprises rectifying amplified carrier wave energy, varying the impedance of said control tube in accordance with the amplitude of said rectified energy, varying the internal impedance of said amplifier tubes in accordance with the impedance of said control tube, and varying the impedance of said control tube in accordance with the anode direct current of said amplifier tubes.

7. In a radio system utilizing one or more amplifier tubes, a demodulator tube, and a control tube, the method of control which comprises rectifying amplified carrier wave energy, varying the impedance of said control tube in accordance with the amplitude of said rectified energy, varying the internal impedance of said amplifier tubes in accordance with the impedance of said control tube, and varying the impedance of said control tube and the grid biasing potential of said demodulator tube in accordance with the anode current of said amplifier tubes.

8. In a radio system utilizing one or more screen grid amplifier tubes, a demodulator tube, and a control tube, the method of control which comprises deriving the grid potential of the control tube from the anode direct current of the demodulator tube, controlling the screen grid potential of said amplifier tubes by said control tube, and varying the anode current of the demodulator tube by change in anode direct current of the amplifier tubes to effect change in the grid potential of said control tube.

9. Radio apparatus comprising cascaded thermionic tubes, a volume control tube for varying the impedance of certain of said tubes, an input circuit therefor including resistance traversed by anode current of another of said tubes, and a resistance common to the anode circuits of at least the controlled

tubes and said other tube for enhancing the control effected by said control tube.

10. Radio apparatus comprising one or more screen grid amplifier tubes, a demodulator tube, a volume control tube for varying the screen grid voltage of said amplifier tubes, and resistance in the anode circuit of said demodulator tube having portions included in the anode circuit of said amplifier tubes and in the grid circuit of said control tube whereby the current flowing through the portion of said resistance in the grid circuit of said control tube is determined by the amplitude of the received energy and the direct current anode current of said amplifier tubes.

11. A radio receiving system comprising a volume control tube, a conductive impedance connected between input electrodes thereof, a detector tube, a direct current source of anode current, connections for including said impedance in the detector anode circuit between the cathode of the detector tube and the negative terminal of said source, one of said connections connecting the grid of the control tube to the cathode of the detector tube, a radio frequency amplifying tube in advance of said detector tube, a second conductive impedance common to the anode circuit of said control tube and a grid circuit of said radio-frequency amplifying tube whereby the grid-biasing potential is regulated by the control tube, and a third conductive impedance common to the anode circuit of said detector tube and another electrode circuit of said amplifier tube for enhancing the control effected by said volume control tube.

12. A radio receiving system comprising at least one radio frequency amplifier tube, a demodulator tube, a volume control tube having means in its input system responsive to change in average value of the anode current of said demodulator tube and means in its output system for changing the biasing potential applied to amplifier tube grid structure in accordance with variation in the average direct current anode current of said demodulator tube, a common source of direct current for electrode circuits of said tubes, and resistance of substantial magnitude traversed by current from said source and common to electrode circuits of said detector and

amplifier tubes whereby the normal control action of said control tube is enhanced by a resulting interaction between said electrode circuits.

13. In a radio system utilizing one or more amplifier tubes, a demodulator tube, and a control tube, the method of control which comprises rectifying amplified carrier wave energy by said demodulator tube, varying the biasing potential applied to grid structure of said control tube in accordance with the average direct current anode current of said demodulator tube, varying the biasing potential applied to amplifier tube grid structure in accordance with the anode current of said control tube, and further varying the direct current anode current of said demodulator tube in accordance with the current in another electrode circuit of said amplifier tube.

14. Radio apparatus comprising one or more screen grid amplifier tubes, a demodulator tube, a volume control tube whose output system controls the bias of grid structure of said amplifier tubes, means in the input system of said control tube for varying its grid bias in accordance with changes in average value of the demodulator anode current, and means for enhancing the control effect of said volume control tube comprising resistance of substantial magnitude common to the anode circuits of said amplifier tubes and of said demodulator tube whereby the magnitude of the demodulator anode current is determined by the amplitude of received carrier energy and the anode current of the amplifier tubes.

15. Radio apparatus comprising cascaded thermionic tubes, a volume control tube whose output circuit controls the impedance of one or more of said tubes, an input circuit for said volume control tube including resistance traversed by anode current of a tube other than said controlled tube or tubes, and a resistance common to the anode circuit or circuits of said controlled tube or tubes and of said last named tube, whereby the magnitude of direct current traversing said first named resistance is determined by the amplitude of received energy impressed upon, and by the direct current in, the anode circuit or circuits of said controlled tube or tubes.

OTTO H. SCHADE.

CERTIFICATE OF CORRECTION.**Patent No. 1,916,129.****June 27, 1933.****OTTO H. SCHADE.**

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, line 16, for "4,000" read 8,000; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 5th day of December, A. D. 1933.

F. M. Hopkins

(Seal)

Acting Commissioner of Patents.