

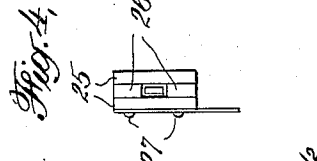
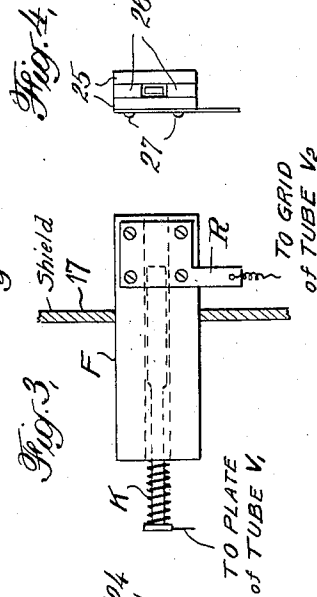
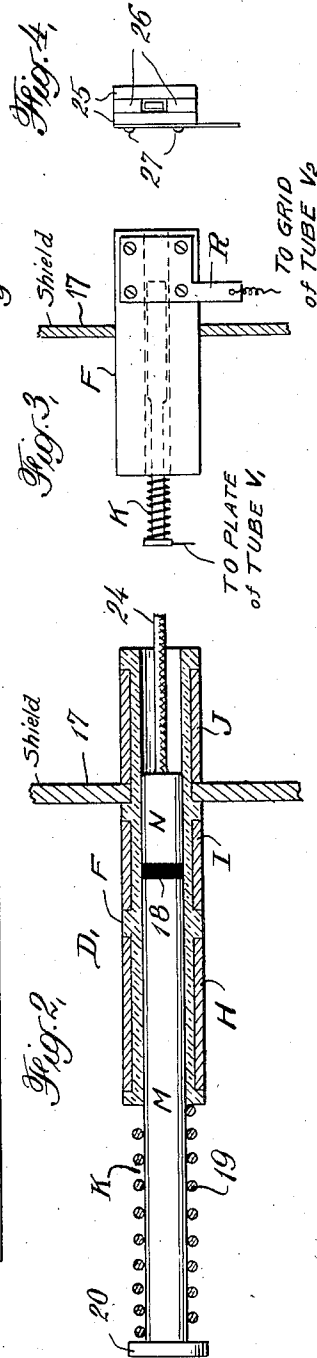
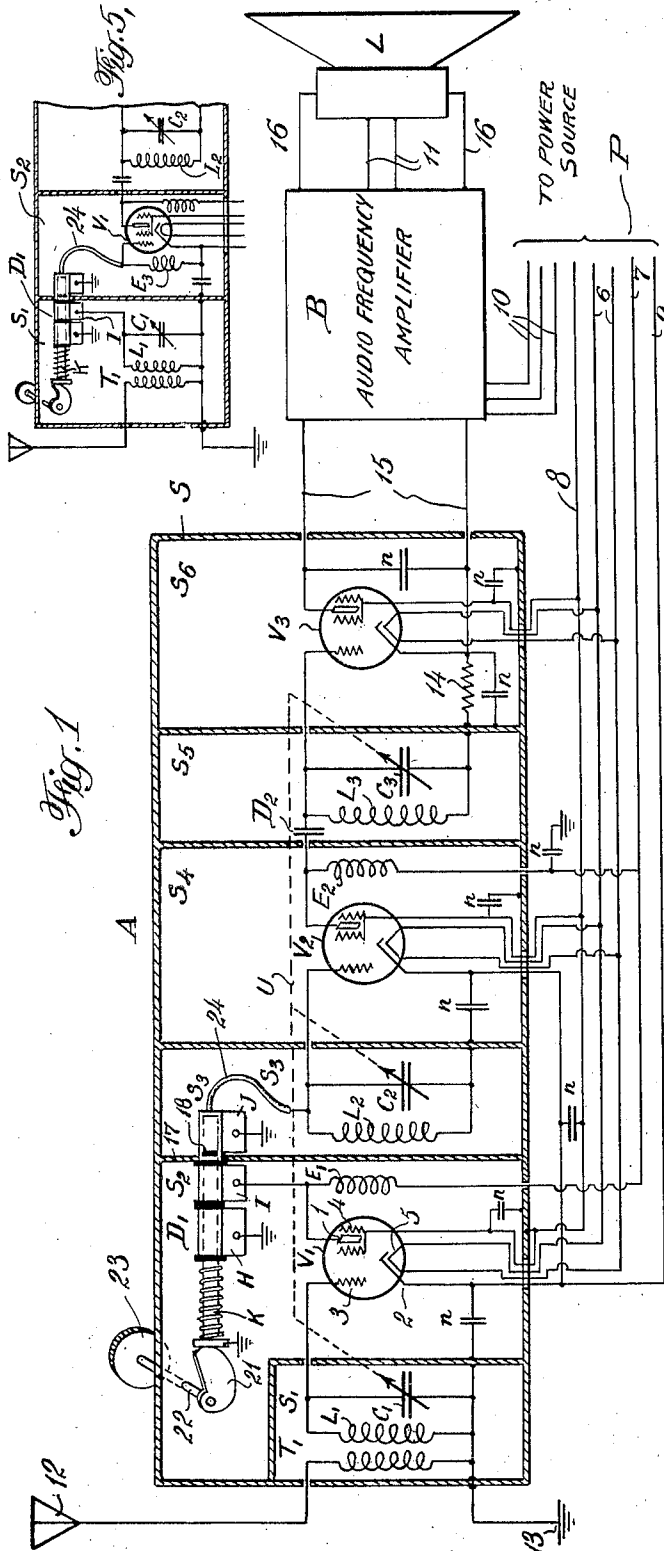
Sept. 17, 1935.

E. F. CARTER ET AL

2,014,422

VOLUME CONTROL FOR RADIO CIRCUITS

Filed July 2, 1930



INVENTORS
E. F. CARTER
H. F. SCHWARZ
BY
Perris, Davis, Kewin & Edwards
ATTORNEYS

UNITED STATES PATENT OFFICE

2,014,422

VOLUME CONTROL FOR RADIO CIRCUITS

Emmett Finley Carter, Flushing, N. Y., and
Harvey Fisher Schwarz, Muskegon, Mich., as-
signors to United Research Corporation, Long
Island City, N. Y., a corporation of Delaware

Application July 2, 1930, Serial No. 465,352

21 Claims. (Cl. 179—171)

This invention pertains to radio receivers, more especially to radio receivers adapted for radio broadcast reception.

A primary object of the invention is to provide a receiver of the type specified embodying an improved type of continuously variable volume control element whereby the volume of the received signal may be quickly and easily adjusted over a wide range of values extending from exceedingly low to high intensities.

In the past two general types of volume control elements have been provided for radio broadcast receivers. One type that has been utilized comprises a variable resistance such as a rheostat bridged across the input section to the receiver. Another and frequently used type comprises a potentiometer arrangement for varying the potential of the cathodes or screen grids of the radio frequency amplifier tubes.

The first arrangement is objectionable in that it is difficult mechanically to construct a suitable high resistance rheostat which will permit variation of the signal intensity over the desired range of values and which at the same time embodies the desirable features of economy and ruggedness. The rheostat method of volume control is further objectionable in that the high resistance utilized renders the receiver noisy. Due to the capacity and resistance of the connecting wires, volume control at low intensities becomes particularly difficult. The adjustment of volume by the rheostat method is in general without effect upon the inherent noise of the set as a consequence of which a reduction of signal intensity does not produce a corresponding reduction of noise in the set, so that the ratio of noise to signal intensity increases as the volume is reduced.

The second arrangement, that of varying the potential of the cathodes or screen grids is objectionable in that any adjustment of the control element changes the operating conditions for the tubes. This causes the tubes in general to be operated at points on their characteristic curves other than the linear portion thereof, which results in an intermodulation of signals with consequent distortion. As a further objection to volume control by this method it has been found in practice that in order to provide a desirable range of volume adjustment it is necessary to work the tubes almost to their cutoff points which causes the signal to be greatly distorted as the cutoff point is approached.

The present invention provides a volume control which overcomes the above objections in

that it is extremely economical of construction, provides continuous volume reduction over a very wide range of values and causes the tubes always to be operative at the straight portion of the tube characteristic, thereby insuring freedom from distortion, modulation, and crosstalk troubles in the radio frequency stages. The design of the space-current supply circuit for the tubes is simplified since with the control of the present invention there is no variation in plate current drawn by the radio-frequency tubes. The control may be made smooth, noiseless, free from wear, and with any desired law of variation in attenuation with angular position of the control dial.

The invention is particularly applicable to the modern type of radio broadcast receiver wherein the various portions of the radio-frequency amplifier are completely shielded from each other by positioning the same in individual metal compartments. The invention is furthermore especially applicable to the receivers wherein capacitive coupling is utilized to couple the output circuit of one tube with the input circuit of the succeeding tube, the output circuit of each tube being in a shielding compartment distinct from that housing the input circuit of the succeeding tube.

As applied to a receiver of this type, the invention comprises a variable coupling condenser connecting the output section of the first radio-frequency stage to the input section of the next succeeding stage. This condenser is of unique construction and consists of a sleeve of insulating material such as bakelite fitted into an aperture in the shield separating the output section of the first radio-frequency tube from the input section of the immediately succeeding tube. A metal plunger is slidable within the bore of the insulating sleeve in such manner that an insulated conductive end portion thereof within the bore may be adjusted from one shielding compartment to the other. A conductive collar is positioned about the insulating sleeve in the shielding compartment containing the output circuit of the first radio-frequency amplifier tube and is conductively connected to the anode electrode thereof. The conductive end portion of the plunger is connected by a flexible lead to the grid electrode of the succeeding radio-frequency tube.

As a result of this arrangement it will be obvious that the coupling capacity may be varied by movement of the plunger. When the plunger is in such position that the insulated end portion and the conductive collar are situated in different

shielding compartments, the capacitive coupling between the first and second tubes is reduced almost to zero due to the interposition of the shield therebetween. When, however, the plunger is withdrawn until the insulated end portion is situated beneath the metal collar the coupling capacity between tubes is a maximum; and for any intermediate setting of the plunger arm, of course, the coupling capacity lies between the two values. It has been found in practice that by adjusting the capacity in this way the received volume may be varied over a range of values having a ratio of as much as 20,000 to 1.

Having thus described the invention in general terms, reference will now be had to the drawing for a detailed explanation of a specific embodiment thereof wherein:

Figure 1 shows partly in circuit diagrammatic form a radio broadcast receiver embodying the novel volume control of the present invention interposed between the first and second radio-frequency stages;

Figure 2 shows a longitudinal cross-section of the control element;

Figures 3 and 4 show a side elevation and an end elevation respectively of a modified form of the volume control element;

Figure 5 is a fragmentary view of Figure 1 disclosing a modified form of the invention wherein the volume control is interposed between the antenna circuit and the input to the first radio-frequency stage.

Referring to Figure 1, there is shown a radio receiver comprising a radio-frequency amplifier and detector unit A, an audio-frequency amplifier B, and a loud speaker unit L.

The radio-frequency amplifier unit A comprises two stages of radio-frequency amplification consisting of screen grid tubes V_1 and V_2 in cascade connection working into a screen grid detector tube V_3 . Each tube comprises an anode 1, cathode 2, grid 3, screen grid 4, and filament or heater element 5. The filaments 5 are connected in multiple over leads 6 to a suitable source of power P for heating the tubes. Likewise, the anodes 1 of the tubes V_1 and V_2 are connected over a lead 7 to the power source P for supplying space-current to the tubes; the screen grids 4 are connected over a lead 8, and the cathodes 2 over a lead 9 to the power source for applying suitable potentials thereto. The audio-frequency amplifier B is connected by means of conductors 10 to the power source for supplying the necessary potentials to the audio-frequency amplifier tubes and also the field current over leads 11 to the loud speaker unit L which is of the "dynamic" type.

An antenna 12 and ground 13 are connected to opposite terminals of the primary winding of a radio-frequency transformer T_1 , the secondary of which is connected between grid 3 and cathode 2 of tube V_1 . A variable condenser C_1 is connected across the secondary winding L_1 of transformer T_1 for tuning the same. The plate electrode 1 of tube V_1 is connected through a radio-frequency choke coil E_1 and thence to lead 7. In addition the plate electrode 1 of tube V_1 is also connected through the special volume control condenser D_1 of the present invention to the grid electrode 3 of the succeeding tube V_2 . Connected between the grid 3 and cathode 2 of tube V_2 is a tunable resonant circuit comprising inductance L_2 and variable capacity C_2 in parallel electrical connection.

The plate electrode of tube V_2 is connected

through a radio-frequency choke coil E_2 similar to E_1 to lead 7, and is further connected through a fixed coupling capacity D_2 to the grid electrode of the succeeding tube V_3 . A tunable circuit comprising inductance L_3 and capacity C_3 is associated with the input section of tube V_3 , one side of the tunable circuit being connected directly to the grid electrode 3 of tube V_3 and the other side being connected through a resistance 14 shunted by a capacity n to the cathode, the latter elements being adapted to cause the tube V_3 to function as a detector tube. The output section of tube V_3 comprising the plate 1 and the cathode 2 are connected over leads 15 to the input section of the audio-frequency amplifier B, the output of which, in turn, is connected by means of leads 16 to the voice-frequency winding of the loud speaker L.

The radio-frequency unit A is completely housed within a grounded metal shielding structure S divided by suitable walls or interposed screens into shielding compartments S_1 to S_6 inclusive. The resonant circuits LC are individually housed within compartments S_1 , S_3 and S_5 respectively, while each tube V together with its output coil E is housed within a compartment S_2 , S_4 or S_6 .

The capacities n are high-frequency by-passing condensers which serve to prevent undesired coupling effects between the various elements of the amplifier which tend to produce undesirable sustained oscillations. The capacity n connected across the output section of tube V_3 serves to bypass the radio-frequency currents and thereby prevent the same from being impressed upon the audio-frequency amplifier B. The condensers C_1 to C_3 , inclusive, are mechanically connected by a uni-control device U for simultaneously tuning all of the circuits LC alike.

The inductance of each choke coil E is selected so that with the plate-to-ground capacity of the corresponding tube V it is resonant at a frequency slightly lower than the tunable range for the resonant circuits LC. Furthermore since each coil E is shielded from the next succeeding tuned circuit LC, the only coupling between circuits is through the corresponding coupling capacity D. The elements E, LC and D are suitably proportioned to produce uniform amplification over the frequency range of the tunable circuit LC, the amount of amplification being determined by and proportional to the magnitude of capacity D. By varying the capacity D from a value of about 7 micro-microfarads to as low a value as possible, the amplification may be controlled over a wide range of values without affecting the frequency characteristics of the receiver. A suitable range of volume control may be obtained in this manner by varying only one of the coupling condensers D such, for example, as the condenser D_1 .

Referring specifically to Figures 1 and 2, the condenser D_1 comprises an insulating sleeve F mounted within an aperture in shielding wall 17 electrically screening the output circuit of tube V_1 from the input circuit of tube V_2 . A plunger K is slidably positioned within the sleeve F, the plunger consisting of a main conductive portion M insulated by a member 18 from a conductive end portion N.

A compression spring 19 positioned about the projecting portion of member M by reacting against the end of sleeve F forces the head 20 of member M at all times into engagement with a cam 21 mounted upon a shaft 22 projecting through the screen S and provided upon its outer

end with a knob 23 for adjusting the position of the plunger.

The sleeve F is provided with turned depressions housing the metal collars H, I and J positioned thereabout. Collars H and I are located in the same shielding compartment S₂ with the output circuit of tube V₁, while collar J is positioned in the shielding compartment S₃ housing the tuned circuit L₂ C₂ connected to the input circuit of tube V₂. The end portion N is connected by a flexible lead 24 to the grid electrode of tube V₂ while collar I positioned adjacent screen 17 but insulated therefrom is connected to the plate electrode of tube V₁. Collars H and J are grounded as is also the conductive portion M of the plunger K as shown in Figure 1.

As a result of this arrangement it will be observed that adjustment of the knob 23 varies the capacity electrostatically coupling the elements I and N thereby adjusting the capacitive coupling existing between the output circuit of tube V₁ and the input circuit of tube V₂.

With the plunger in the position shown in Figure 1 the capacity between elements I and N is a minimum due to the interposition of the grounded shield 17 therebetween, which effectively shields one said element from the other. This shielding effect is made more complete by the fact that the end of conductive member M substantially fills up the hole in screen 17 which houses the sleeve F.

If now the knob 23 is so rotated that member N is displaced from shielding compartment S₃ to shielding compartment S₂, the capacity between elements I and N will gradually increase to a maximum value attained when member N is situated substantially beneath member I thus providing a maximum degree of coupling between the stages V₁ and V₂ of the amplifier A. Figure 2 shows the plunger adjusted to a position intermediate between the maximum and minimum capacity values.

Due to the extremely low capacity obtainable between elements I and N when the screen 17 is interposed therebetween, it is possible to obtain an extremely wide range of adjustment for the signal intensity impressed from the output circuit of tube V₁ through the coupling capacity D₁ upon the input circuit of tube V₂. The minimum capacity adjustment of the condenser is further reduced by the provision of the grounded collars H and J and the grounded portion M of the plunger. This results from the fact that with the plunger in the position shown in Figure 1 there is a relatively large capacity to ground from the grid electrode of tube V₂ due to the fact that the end portion N is situated directly beneath the grounded collar J. Likewise there is a relatively large capacity to ground from the plate electrode of tube V₁ due to the fact that the conductive portion M of the plunger is situated beneath collars I and H. These grounded capacities serve to reduce the voltage impressed across the coupling capacity D₁ between stages comprising the elements I and N.

Figures 3 and 4 disclose a modified form of the invention wherein the plunger K comprises a single conductive member slidably housed within a sleeve F consisting of the insulating plates 25 and 26 held together in rigid assembly by means of screws 27. The sleeve F is positioned within an aperture in the shield 17. A conductive plate R is mounted upon the outer side of the sleeve F on one side of the shield 17.

In the operation of this device the plunger K is conductively connected to the plate electrode

of tube V₁ and the plate R to the grid electrode of tube V₂, or the connections may be reversed if desired. With this arrangement it will be obvious that the capacity between elements K and R is adjusted from a maximum value with a portion of the plunger K projecting through the screen and positioned adjacent the plate R, to a low minimum value with the plunger wholly withdrawn to the opposite side of the screen.

By suitably shaping the cam 21 the volume may be caused to vary in any desired manner with angular adjustment of the knob 23.

With the arrangement of Figure 1, the full signal intensity is impressed upon the input to the first radio frequency tube V₁. This may be undesirable where powerful stations operate in the vicinity of the receiver or where powerful signals are being received. Under such conditions the circuit modification of Figure 5 becomes preferable, in which the volume control condenser D₁ variably couples the antenna circuit to the input of tube V₁.

In Figure 5 the antenna circuit is similar to that of Figure 1. The high potential terminal of the tuned circuit L₁ C₁, instead of being connected directly to the grid of tube V₁ as formerly, is now coupled to the collar I of condenser D₁ mounted in the partition separating screening compartments S₁ and S₂, the conductive end portion of the piston K being connected by flexible lead 24 to the grid of tube V₁. A radio-frequency choke coil E₃ is connected between grid and cathode of tube V₁ to suitably adjust the input impedance relations.

We claim:

1. A multi-stage thermionic amplifier wherein the output section of one stage is variably coupled capacitively to the input section of the succeeding stage, means electrically shielding said sections including a conductive screen interposed therebetween, said capacity comprising a fixed element connected to one said section and positioned on the same side of said screen therewith, and a conductive plunger connected to the other said section and insulatedly slidable through a slot in said screen adjacent said fixed element, for varying the capacity from a maximum value with said plunger adjacent said fixed element, to a low minimum value with the plunger withdrawn to the opposite side of said screen.

2. A multi-stage thermionic amplifier comprising vacuum tubes in cascade connection, each having anode, cathode and grid electrodes, means electrically shielding the output section of one said tube from the input section of the succeeding tube, said means including a conductive screen interposed therebetween, a variable capacity connected from the anode electrode of said first tube to the grid electrode of said succeeding tube, said capacity comprising a fixed element connected to one said electrode and positioned on the same side of said screen therewith, and a conductive plunger connected to the other said electrode and insulatedly slidable through a slot in said screen adjacent said fixed element for varying the capacity from a maximum value with said plunger positioned adjacent said fixed element, to a low minimum value with the plunger withdrawn to the opposite side of said screen.

3. A multi-stage thermionic amplifier comprising vacuum tubes in cascade connection, each having a grid and a cathode comprising said input section and said cathode and an anode comprising an output section, an impedance connected to the output section of one said tube, an imped-

ance connected to the input section of the succeeding tube, means electrically shielding said output and said input sections including a conductive screen interposed therebetween, a variable capacity connected from the anode electrode of said first tube to the grid electrode of said second tube, said capacity comprising a fixed element connected to one said electrode and positioned on the same side of said screen therewith, and a conductive plunger connected to the other said electrode insulatedly slidable through a slot in said screen adjacent said fixed element for varying the capacity from a maximum value with said plunger positioned adjacent said fixed element to a low minimum value with plunger withdrawn to the opposite side of said screen.

4. A multi-stage thermionic amplifier comprising vacuum tubes in cascade connection each having grid and cathode electrodes comprising an input section and said cathode and an anode electrode comprising an output section, an impedance connected to the output section of one said tube, a resonant circuit tunable over a range in frequency connected to the input section of the succeeding tube, means electrically shielding said output section from said tunable circuit, said means including a conductive screen interposed therebetween, a variable condenser connected from the anode electrode of said first to the grid electrode of said succeeding tube, said condenser comprising a fixed element connected to one said electrode and positioned on the same side of said screen therewith, and a conductive plunger connected to the other said electrode and insulatedly slidable through a slot in said screen adjacent said fixed element for varying the capacity from a maximum value with a portion of said plunger positioned adjacent said fixed element, to a low minimum value with the plunger wholly withdrawn to the opposite side of said screen.

5. In combination, a pair of electrical circuits, means electrically shielding said circuits including a conductive screen interposed therebetween grounded to one side of each said circuit, a variable condenser capacitively coupling the ungrounded sides of said circuits comprising, a fixed element connected to one said circuit and positioned on the same side of the screen therewith, and a conductive plunger connected to the other said circuit and insulatedly slidable through a slot in said screen for varying the capacity between said fixed element and said plunger from a maximum value with a portion of said plunger positioned adjacent said fixed element to a low minimum value with said plunger displaced to the opposite side of said screen.

6. In combination, a pair of electrical circuits, means electrically shielding said circuits including a conductive screen interposed therebetween grounded to one side of each said circuit, a variable condenser capacitively coupling the ungrounded sides of said circuits comprising, an insulating sleeve mounted in an aperture in said screen, a plunger slidable within said sleeve including an insulated conductive end portion, adapted to be displaced from one side of said screen to the other, a conductive collar placed about said sleeve on one side of said screen and connected to the said circuit adjacent thereto, means connecting said conductive end portion to the other said circuit whereby the capacity of said condenser may be varied from a maximum to a low minimum value as said conductive end portion is displaced from one side to the other of said screen.

7. A multi-stage high-frequency amplifier tunable over a range in frequency comprising vacuum tubes in cascade connection wherein the output circuit of a first tube includes an impedance tuned to a frequency slightly below said range and the input circuit of the succeeding tube includes a resonant circuit tunable over said frequency range, means electrically shielding said output and input circuits, said means including a conductive screen interposed therebetween, a capacity connecting the anode electrode of said first to the grid electrode of said succeeding tube, said capacity comprising a stator positioned on the same side of said screen with the said electrode connected thereto, and a conductive plunger connected to the other said electrode and insulatedly slidable through a slot in said screen adjacent said stator for varying said capacity from a maximum value with said plunger positioned adjacent said stator to a low minimum value with said plunger wholly withdrawn to the opposite side of said screen whereby the signal intensity impressed from said output upon said input circuit may be varied over a wide range.

8. An amplifier in accordance with claim 7 wherein said impedance, capacity and tuned circuit are proportioned to provide substantially uniform amplification over said range in frequency.

9. A multi-stage high-frequency amplifier comprising thermionic tubes in cascade connection each having a grid and cathode comprising an input section, and said cathode and an anode comprising an output section, a fixed impedance connected in the output circuit of one tube and a tunable impedance in the input circuit of the succeeding tube, means electrically shielding said output and input circuits including a conductive screen interposed therebetween grounded to said cathodes, means adjustably controlling the signal intensity impressed upon said input from said output circuit comprising, a variable condenser connected from the anode of said first to the grid of said succeeding tube, said condenser consisting of a fixed element positioned on the same side with and connected to one said electrode, and a conductive plunger connected to the other said electrode and insulatedly slidable through a slot in said screen, for adjusting the capacity of said condenser from a maximum to a low minimum value as said plunger is displaced from a position adjacent said fixed element to the opposite side of said screen therefrom.

10. A multi-stage high-frequency amplifier comprising thermionic tubes in cascade connection each having a grid and cathode included in an input circuit and said cathode and an anode included in an output circuit, a fixed impedance connected in the output circuit of one tube and a tunable impedance in the input circuit of the succeeding tube, means electrically shielding said output and input circuits including a conductive screen interposed therebetween grounded to said cathodes, means adjustably controlling the signal intensity impressed upon said input from said output circuit comprising, a variable condenser connected from the anode of said first to the grid of said succeeding tube, an insulating sleeve positioned within an aperture in said screen, a conductive collar placed thereabout on the same side of said screen with and connected to one said electrode, a plunger slidable within said sleeve comprising a conductive end portion insulated from a conductive main portion, said end

portion being connected to the other said electrode for adjusting the coupling capacity between said electrodes from a maximum to a low minimum value as said end portion is displaced from a position adjacent said collar to the opposite side of said screen therefrom.

11. In an amplifier as set forth in claim 12 additional means for further reducing the minimum capacity adjustment of said condenser consisting of a second conductive collar positioned about said sleeve on the same side with and longitudinally displaced from said first collar, and a third conductive collar positioned about said sleeve on the opposite side of said screen, said main plunger portion being positioned on the same side of said screen with said first and second collars, means grounding said second and third collars and said main plunger portion to said screen whereby with said end portion and said first collar positioned on opposite sides of said screen there exists relatively large capacities from said anode and grid electrodes to ground at said shield through said second and third collars and the conductive portions of said plunger which capacities greatly reduce the effect of said coupling capacity between said electrodes.

12. The combination in a radio receiving system of an exciting circuit including an impedance, an absorbing circuit including a second impedance, a shield therebetween, and means comprising a variable capacity coupling said impedances for varying the signal intensity impressed from said exciting upon said absorbing circuit and for varying the volume of reproduction over a wide range.

13. The combination in a radio receiving system of a high frequency exciting circuit and an absorbing circuit, at least one of which is tunable over a range in frequency, a pair of impedances individual to said circuits, a shield member therebetween, and means comprising a variable capacity connected between said impedances for adjusting the signal intensity impressed from said exciting upon said absorbing circuit and for varying the volume of reproduction over a wide range.

14. The combination in a radio receiving system of a high-frequency exciting and a high-frequency absorbing circuit, at least one of which is tunable over a range in frequency, a pair of magnetically uncoupled impedances individual to said circuits, a shield therebetween, a conductive path extending from a point of the first to a point of the second impedance, and means comprising a variable capacity connected from a different point of the first to a different point of the second impedance for adjusting the signal intensity impressed from said exciting upon said absorbing circuit and for varying the volume of reproduction over a wide range.

15. The combination in a radio receiving system of a high-frequency exciting and a high-frequency absorbing circuit, at least one of which is tunable over a range in frequency, a pair of magnetically uncoupled impedances individual to said circuits with a conductive screen interposed therebetween grounded to a point of each said impedance, and a variable capacity connected from a different point of said first to a different point of said second impedance for adjusting the signal intensity impressed from said exciting upon said absorbing circuit, said capacity comprising a fixed plate connected to one said impedance element and positioned on the same side of the screen therewith, and a variable plate connected to the other said impedance and slidably adjustable through an aperture in said screen from one side to the other thereof.

16. The combination in a radio receiving system of a vacuum tube amplifier stage, an input circuit connected thereto, a preceding radio circuit feeding therein, a shield member therebetween, a coupling condenser cooperating therebetween and comprising separate fixed members on opposite sides of said shield and a movable plate member connected to said input circuit and movable between said fixed plates through said shield.

17. The combination in a radio receiving system of a plurality of radio circuits and a variable coupling member operating for connection therebetween, comprising a plurality of separate electrically insulated stationary plates, a movable plate cooperating therebetween and a rotatable handle member for adjusting the position of said movable plate.

18. A plurality of circuits, a shield therebetween, and a condenser for coupling said circuits mounted on said shield.

19. A plurality of circuits, a shield therebetween, and having an aperture, and a condenser for said circuits mounted in said aperture.

20. A plurality of circuits, a shield therebetween, and a condenser for coupling said circuits and having a plate adapted to project more or less beyond one side of said shield.

21. The combination in a radio receiving system of a vacuum tube having an output circuit, a coil therein, a second vacuum tube having an input circuit, a coil in said input circuit, a shield between said coils, a flexible conductor connected at one end to said input circuit and having the other end thereof movable, and means for moving the movable end of said flexible conductor to selectively connect said input circuit around said shield to said output circuit.

EMMETT FINLEY CARTER.
HARVEY FISHER SCHWARZ.