Sept. 9, 1930. A. A. KENT 1,775,399

RECEIVING SYSTEM

Filed Jan. 27, 1928 2 Sheets-Sheet 1

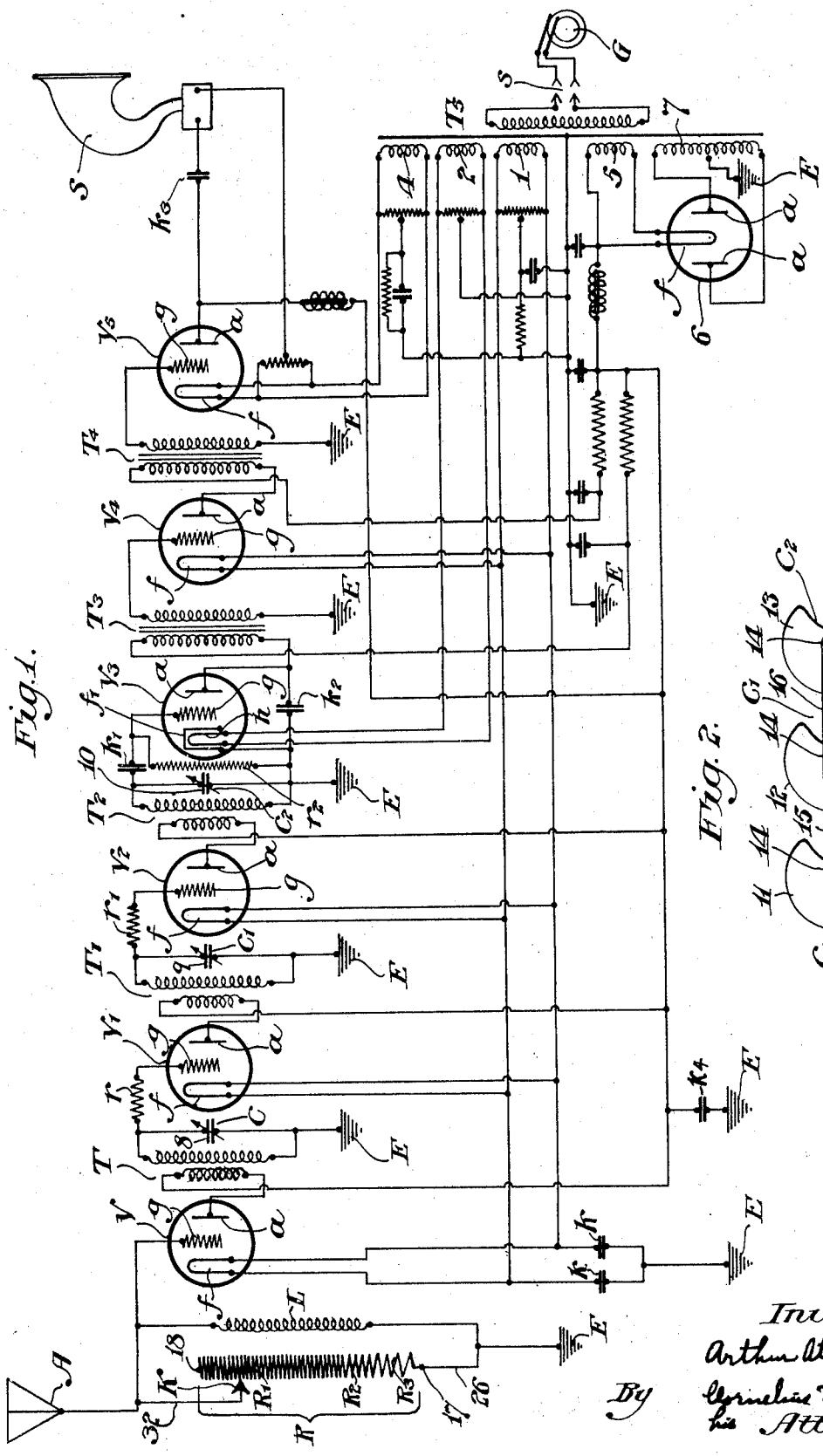


Fig. 1.

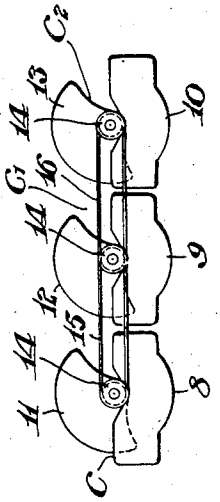


Fig. 2.

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Fig. 4.

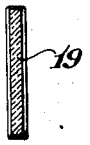


Fig. 7.

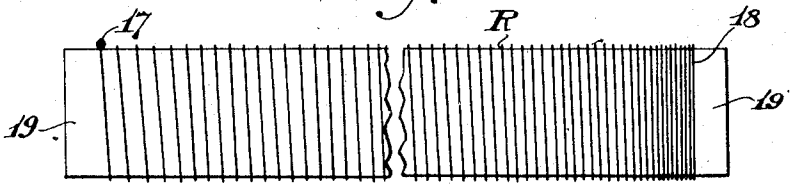


Fig. 3.

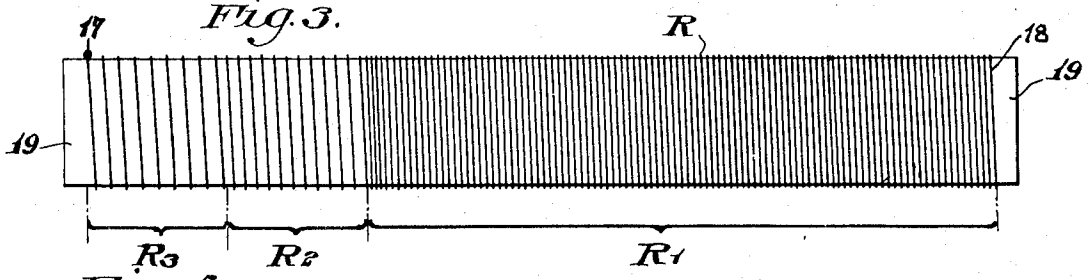


Fig. 5.

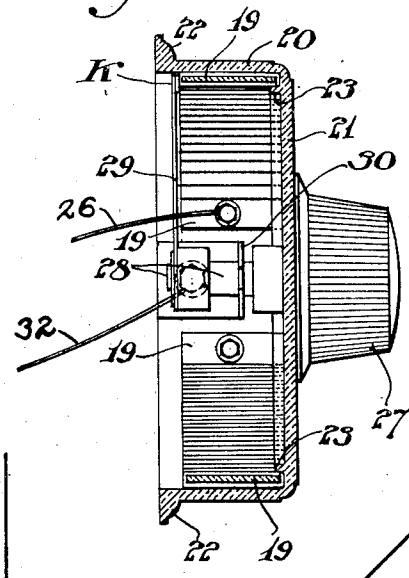


Fig. 6.

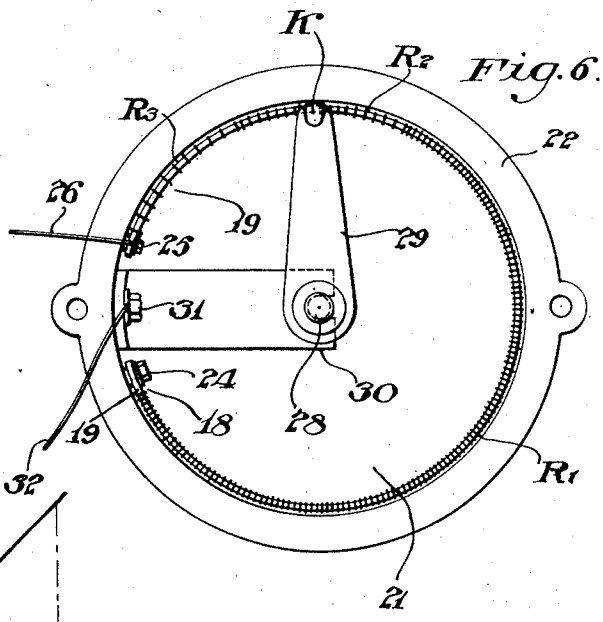
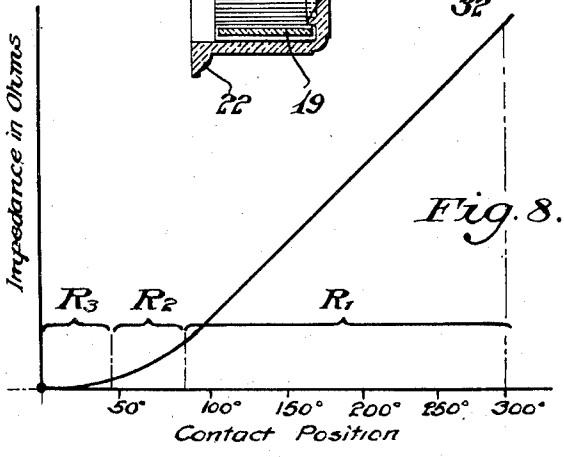


Fig. 8.



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UNITED STATES PATENT OFFICE

ARTHUR ATWATER KENT, OF ARDMORE, PENNSYLVANIA

RECEIVING SYSTEM

Application filed January 27, 1928. Serial No. 249,785.

My invention relates to the control of magnitude of amplification or volume of reproduction of speech, music and other signals, in radio receiving systems, more particularly in those in which the source of power for the anode circuits and for heating the cathodes of thermionic vacuum tubes is of the alternating current type.

In accordance with my invention a resistance, which may be non-inductive or more or less inductive, is operatively related to the input system or circuit of a thermionic vacuum tube, of the audion type, comprised in a radio receiving system, and more particularly to the input system or circuit of an amplifier tube, more especially a radio frequency amplifier tube, and preferably to the input system or circuit of the first-stage radio frequency amplifier, and is variable by a co-acting control contact smoothly and gradually to change its shunting effect upon the input system or circuit with which it is operatively related to effect the desired volume control. The resistance variation is characterized by the fact that for equal increments of movement of the control contact there are effected smaller magnitudes of resistance change in the region corresponding to low volume than in the region corresponding to higher volume, and to this end the resistance conductor is so wound or disposed upon a form or support that the spacing of the turns of the resistance conductor increases from the region of high to the region of low volume, and, more particularly, the resistance conductor comprises two or more sections in which the spacing of turns is greater in a section adjacent the region corresponding to low volume than in a section adjacent the region corresponding to high volume.

More particularly the variable resistance of the character aforesaid is associated with the first-stage radio frequency amplifier tube, operating as a coupling tube between the antenna or other absorption structure and a circuit or circuits tunable throughout a wave length range without effect thereon by the input system or circuit of the coupling tube whose inductance and capacity remain substantially constant throughout the tuning range notwithstanding variation of the volume-controlling resistance; and where the coupling tube intervenes between the antenna or absorption structure and a plurality of cascaded tunable circuits the movable elements of their tuning devices may be mechanically coupled for operation in unison.

My invention resides in a system of volume control of the character hereinafter described and claimed.

For an understanding of my invention and for an illustration of some of the various forms it may take, reference is to be had to the accompanying drawings, in which:

Fig. 1 is a diagrammatic view of a receiving system embodying my invention.

Fig. 2 is an elevational view of tuning condensers whose rotors are mechanically coupled.

Fig. 3 is a side elevational view of a resistance unit.

Fig. 4 is a cross-sectional view, partly in elevation, of the unit shown in Fig. 3.

Fig. 5 is a sectional view, partly in elevation, illustrative of the mounting of the resistance unit and its co-acting control contact.

Fig. 6 is an end elevational view of the structure shown in Fig. 5.

Fig. 7 is a side elevational view of a modified form of resistance unit.

Fig. 8 is a graph illustrative of the characteristic of the volume control.

Referring to Fig. 1, the received electro-radiant energy is absorbed by the antenna A or any other equivalent absorption structure. In the example illustrated V is a thermionic radio frequency amplifier tube utilized as a coupling tube in the first-stage of a cascade of radio frequency amplifying, detecting and audio frequency amplifying tubes. Its grid g is connected to the antenna A while its cathode or filament f is connected to earth or countercapacity E through the condensers k, k which exhibit low reactance at the radio frequencies involved. Connected between grid g and earth or countercapacity E is the radio frequency choke coil L which substantially completely prevents passage of radio frequency current therethrough, but serves as a

by-pass for low or audio frequency disturbances to prevent any substantial effect thereof upon the grid *g*.

In the circuit of the anode or plate *a* of the tube V is the primary of a radio frequency transformer preferably having high step-up ratio and whose secondary is shunted by the variable tuning condenser C one of whose terminals is connected to earth E and the other through the stabilizing resistance *r*, generally of several hundred ohms, to the grid *g* of the radio frequency amplifier tube V^1. In the anode circuit of the latter is the primary of a second radio frequency step-up transformer T^1 whose secondary is shunted by the variable tuning condenser C^1 one of whose terminals is grounded at E and the other of which connects through a stabilizing resistance r^1 with the grid *g* of the radio frequency amplifier tube V^2 in whose anode circuit is the primary of a step-up radio frequency transformer T^2 whose secondary is shunted by the variable tuning condenser C^2 one of whose terminals is connected to E and the other connects through the small grid condenser k^1 to the grid *g* of the detector tube V^3 having the equi-potential cathode f^1 brought to incandescence by the heater *h* traversed by alternating current. Between the grid *g* and cathode f^1 is connected the grid leak resistance r^2 of high magnitude. Between the cathode f^1 and the anode *a* is connected the condenser k^2, and in the anode circuit is the primary of the audio frequency transformer T^3 whose secondary is in the input circuit of the audio frequency amplifier tube V^4 whose anode circuit is coupled by the audio frequency transformer T^4 with the input circuit of the audio frequency amplifier tube V^5 in whose anode circuit are connected the condenser k^3 and the reproducing or signal translating instrument, such as a loud speaker S.

G represents generically any source of alternating current, such for example one delivering current at a frequency of 60 cycles per second. Through a lamp socket or other equivalent switching or connecting means *s* the primary of the transformer T^5 is connected with the source G. The transformer T^5 has several secondary windings of which 1 supplies so-called "raw" alternating current to the filaments of the tubes V, V^1, V2 and V^4; 2 supplies alternating current to the heater *h* of the detector tube V^3; and 4 supplies alternating current to the filament of the power amplifying tube V^5. The secondary 5 delivers alternating current to the filament of the double-wave rectifying tube 6 whose anodes are connected to opposite ends of the secondary 7. With these transformer secondaries are associated resistances, condensers, and choke coils, constituting an alternating current power unit for supplying current for heating the cathodes of the several tubes, and for supplying filtered rectified alternating current at various suitable voltages for the anode circuits of the tubes.

A system of the character above described is a typical tuned radio frequency amplifier receiving utilizing alternating current or socket power.

The input system of tht first tube V^1 comprising the antenna and earth connections and the choke coil L, which latter may be omitted if suitable or desirable, is of substantially constant inductance and capacity with the result that there is no reactive effect, due to the intervention of the tube V, upon the first tuned comprising the condenser C. It is therefore practicable to mechanically couple the rotors of the several tuning condensers C, C^1 and C^2 for single dial tuning or uni-control. Such mechanical coupling is indicated in Fig. 2 in which the several condenser stators are indicated at 8, 9 and 10 and their cooperating rotors are indicated at 11, 12 and 13. On the shafts of the rotors are pulleys 14 coupled by the bands or belts 15 and 16 which may be of metallic ribbon. The rotors and stators of the tuning condensers are of such character that in their cooperation equal increments of angular adjustment of their rotors effect equal increments of capacity change.

The volume control resistance R is connected at its one terminal 17 with earth E or cathode *f* of the tube V. Movable along the resistance is the control contact K connected to the grid *g* of the tube V. By moving the contact K along the resistance R there is produced a variable shunting effect upon the input system or circuit of the tube V, decreasing the potential of grid *g* as the contact K is moved towards the terminal 17. Accordingly the signal effect impressed upon the tube V is varied, with resultant control of the volume of the sounds emitted by the radio speaker S.

The conductor of the resistance R is preferably of high specific resistance, such as advance wire or the like. The spacing of the turns however is different at different positions along the resistance R from its upper end 18 to its terminal 17. In the example illustrated resistance R comprises three serially connected sections R^1, R^2 and R^3. The turns of section R^1 are closely spaced, those of R^2 more widely spaced, and the spacing of the turns of the section R^3 are still more widely spaced. The resistance R is more or less inductive when constructed as hereinafter described. In consequence not only the resistance but also the inductance of R in shunt to the input terminals of the tube V is varied by adjustment of the control contact K.

As indicated in Figs. 3 and 4 the conductor of the resistance R is wound in the form of a

thin or flat helix upon the strip or plate of insulating material 19. As indicated the several sections R^1, R^2 and R^3 have their turns differently spaced, with the result that per unit length along the edge of the unit the resistance and inductance are greatest in section R^1, less in section R^2, and still less in section R^3. For example the section R^1 may be 4½ inches long, 120 turns per inch; the section R^2 may be 1 inch long, 60 turns per inch; and section R^3, 1 inch long, 40 turns per inch. The conductor throughout the several sections may be Advance or other suitable wire, about No. 36 gauge. When the strip 19 is 1/2 inch wide and about 1/16 inch thick the entire non-inductive resistance of the three sections is about 460 ohms, with an inductance of about 75 microhenrys of which about 66 microhenrys are in the section R^1, 6.2 microhenrys in the section R^2, and 2.8 microhenrys in the section R^3.

In lieu of winding the resistance conductor in two or more sections, with the turns in each section uniformly spaced, but differently spaced in the different sections, the conductor may be wound, as indicated in Fig. 7, with continuous and progressive increase in spacing of the turns from the end 18 to the terminal 17.

Furthermore in both Figs. 3 and 7 the width of the form 19 may taper from one end to the other. It may be wider at the end adjacent the terminal 17 than at the end 18, or, and preferably, it may be narrower adjacent the terminal 17 than at the end 18.

The resistance unit of Fig. 3 or 7 may be suitably mounted with relation to its control contact K as indicated in Figs. 5 and 6, in which however there is illustrated the sectioned resistance unit of Fig. 3.

A circular housing or casing 20, preferably of molded insulating material such as bakelite, has an integral top 21 and base flange 22. Integral with the top 21 is an annular rib 23 spaced from the wall 20 to form an annular groove in which is set the resistance unit by bending it and its strip 19 into circular form. The ends of the strip 19 are secured by bolts or screws 24 and 25 which latter also constitutes the terminal 17 with which communicates a connecting conductor 26. The rotatable operator's knob 27 is secured to the shaft 28 which has a bearing carried by the top 21. Secured to the metallic shaft 28 is the contact arm 29 whose outer end constitutes the control contact K which is movable along the edge of the resistance unit. A conducting member 30 maintains electrical contact with the shaft 28 and therefore with the contact K and has its outer end secured to the casing 20 by the nut 31 which serves also as a binding post for the connecting conductor 32. At the end 18 of the resistance unit the contact K may pass off of the resistance conductor and thereby open the shunting circuit including the resistance unit. When so out of contact for a given amplitude of radio frequency energy absorbed by the antenna A the potential of grid g of the tube V is at maximum and is not to any appreciable extent reduced by the shunting choke coil L whose inductance may be of the order of 1600 microhenrys for a receiving system tunable throughout a wave length range from about 200 to about 600 meters. To reduce the volume the contact K is brought on to the end 18 of the resistance unit whereupon there is immediately some shunting effect which reduces the effective potential of the grid of the tube V with a consequent reduction in volume of reproduction at the speaker S. As the contact K moves along the section R^1 the resistance and inductance change per unit length of movement of the contact K^1 is of the same magnitude throughout traverse of the section R^1, is less during traverse of the section R^2, and is still less in traversing section R^3. The result is an increase of shunting effect, and therefore decrease of potential in the grid g of the tube V, as the contact K is moved from the end 18 toward the terminal 17. Inasmuch as the turns are more widely spaced in sections R^2 and R^3 than in section R^1, the inductance per turn of resistance conductor is greatest in section R^1, less in section R^2, and still less in section R^3, while the non-inductive resistance per turn is practically the same throughout all the sections. At a given frequency of the received energy the inductive reactance in the section R^3 is smaller in comparison to the non-inductive resistance than in section R^2, and in the latter again the inductive reactance is smaller in comparison with the non-inductive resistance than in the section R^1. In the high volume region of control, adjacent the end 18 the change of impedance, at a given frequency, is relatively great per unit movement of the contact k and it requires no particular nicety of rotatable adjustment of the knob 27 to effect desired change in volume. However at the region of low volume control, toward or adjacent the terminal 17, to effect a given percentage change in volume requires a much smaller change in impedance and this implies a smaller or nicer adjustment of the knob 27. To obviate this fineness or nicety of adjustment, the impedance change per unit of movement of the contact K is much less due to the increased spacing of the resistance turns. By utilizing a plurality of sections having different impedance characteristics a smooth and gently changing volume control is possible and particularly in the section R^3 the impedance variation may be said to be accomplished predominatingly by change of resistance rather than by change of inductance; and to lesser extent the same is true of section R^2.

In Fig. 8 there is graphically illustrated the general nature of the volume control effected at 400 meters, for example. Ordinates are magnitudes of impedances, and abscissæ are dial positions or positions of the contact K or knob 27 in degrees departure from end 17 of the resistance unit.

For the range covered by the resistance section R^3 the impedance change is shown to be small and occupying as much as about 40 degrees of movement of the contact K. In the section R^2 the impedance change is greater per unit movement of the contact K and again about 40 degrees of movement of the contact are required to traverse this section. In the section R^1 the impedance change per unit of movement of the contact is still greater and to traverse that section the contact moves about 220 degrees. The changes in volume for the different positions of the contact K are in a general way similar to the impedance changes.

For other frequencies within the range of tuning of the set the characteristics will generally be similar to that of Fig. 8. For wave lengths shorter than 400 meters the characteristics will rise more rapidly, and for wave lengths greater than 400 meters the characteristics will rise less rapidly.

While a resistance unit R which is non-inductive is suitable for volume control, and is preferable, nevertheless from practical considerations it is preferred to construct the unit by winding its conductor upon a form, with the result that there inheres in the unit some inductance. With such inductance present however the magnitude of its change per unit of movement of the control contact K is, as described, made small in the region of low volume control, whereby both the resistance and inductance changes per unit of movement of the control contact K in the region of low volume control are smaller than in the region of high volume control.

It will be understood that my invention is not limited to the use of control resistance with mechanical coupling of the rotors of the tuning condenser, since those rotors may be independently operable if desired.

While the circuit arrangement herein disclosed is shown as one stabilized by use of the resistances R and R^1 in association with reversed poling of the radio frequency coupling transformers it will be understood that other systems of stabilization or of neutralization may be utilized.

A control resistance R of the character herein described may be utilized in other positions than that indicated in Fig. 1. Such a resistance may be connected in shunt with the primary of one or more of the coupling transformers T, T^1 and T^2, and when two or more are utilized the control contacts may be mechanically coupled for adjustment in unison, and they may be staggered so that circuit is closed through them dissimultaneously at their ends 18, as disclosed in my copending application Serial No. 245,851, filed January 11, 1928.

For brevity the term "resistance" as employed in the appended claims shall be understood to comprehend both non-inductive and inductive resistances.

What I claim is:

1. A radio receiving system comprising the combination with an absorption structure, of a receiving set comprising a plurality of thermionic devices in cascade, and a signal-reproducing instrument, the input electrodes of the first of said cascaded devices operatively related to said absorption structure, and means for controlling the magnitude of response of said instrument comprising a wound resistor and a cooperating control contact disposed in a path effectively in shunt to said input electrodes, the resistance change per turn being uniform and the inductance change per turn being of different magnitudes whereby equal increments of movement of said control contact along said resistor effect different impedance changes.

2. A radio receiving system comprising the combination with an absorption structure, of a receiving set comprising a plurality of thermionic devices in cascade, and a signal-reproducing instrument, the input electrodes of the first of said cascaded devices operatively related to said absorption structure, and means for controlling the magnitude of response of said instrument comprising a wound resistor and a cooperating control contact disposed in a path effectively in shunt to said input electrodes, said resistor being of uniform resistance per unit length of conductor and the convolutions thereof so disposed that equal increments of movement of said control contact along said resistor effect smaller impedance changes in a region of low than in a region of high magnitude of response of said instrument.

3. A radio receiving system comprising the combination with an absorption structure, of a receiving set comprising a plurality of thermionic devices in cascade, and a signal-reproducing instrument, the input electrodes of the first of said cascaded devices operatively related to said absorption structure, and means for controlling the magnitude of response of said instrument comprising a resistance and a cooperating control contact disposed in a path effectively in shunt to said input electrodes, the resistance conductor disposed in turns whose spacing increases in the direction of movement of said control contact from region of high to region of low magnitude of response of said instrument.

4. A radio receiving system comprising the combination with an absorption structure, of a receiving set comprising a plurality of thermionic devices in cascade, and a signal-

reproducing instrument, the input electrodes of the first of said cascaded devices operatively related to said absorption structure, and means for controlling the magnitude of response of said instrument comprising a resistance and a cooperating control contact disposed in a path effectively in shunt to said input electrodes, said resistance comprising serially connected sections, each section comprising equally spaced turns of the resistance conductor, the spacing of turns in a section corresponding to lower magnitude of response of said instrument being greater than in a section corresponding to higher magnitude of response of said instrument.

5. A radio receiving system comprising the combination with a thermionic device, input and output systems therefor, an impedance in one of said systems, a signal-reproducing instrument operatively related to said output system, and means for controlling the magnitude of response of said instrument comprising a wound resistor and a cooperating control contact disposed in a path effectively in shunt to said impedance, said resistor being of uniform resistance per turn and the turns so disposed that equal increments of movement of said control contact along said resistor effect smaller impedance changes in a region of low than in a region of high magnitude of response of said instrument.

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