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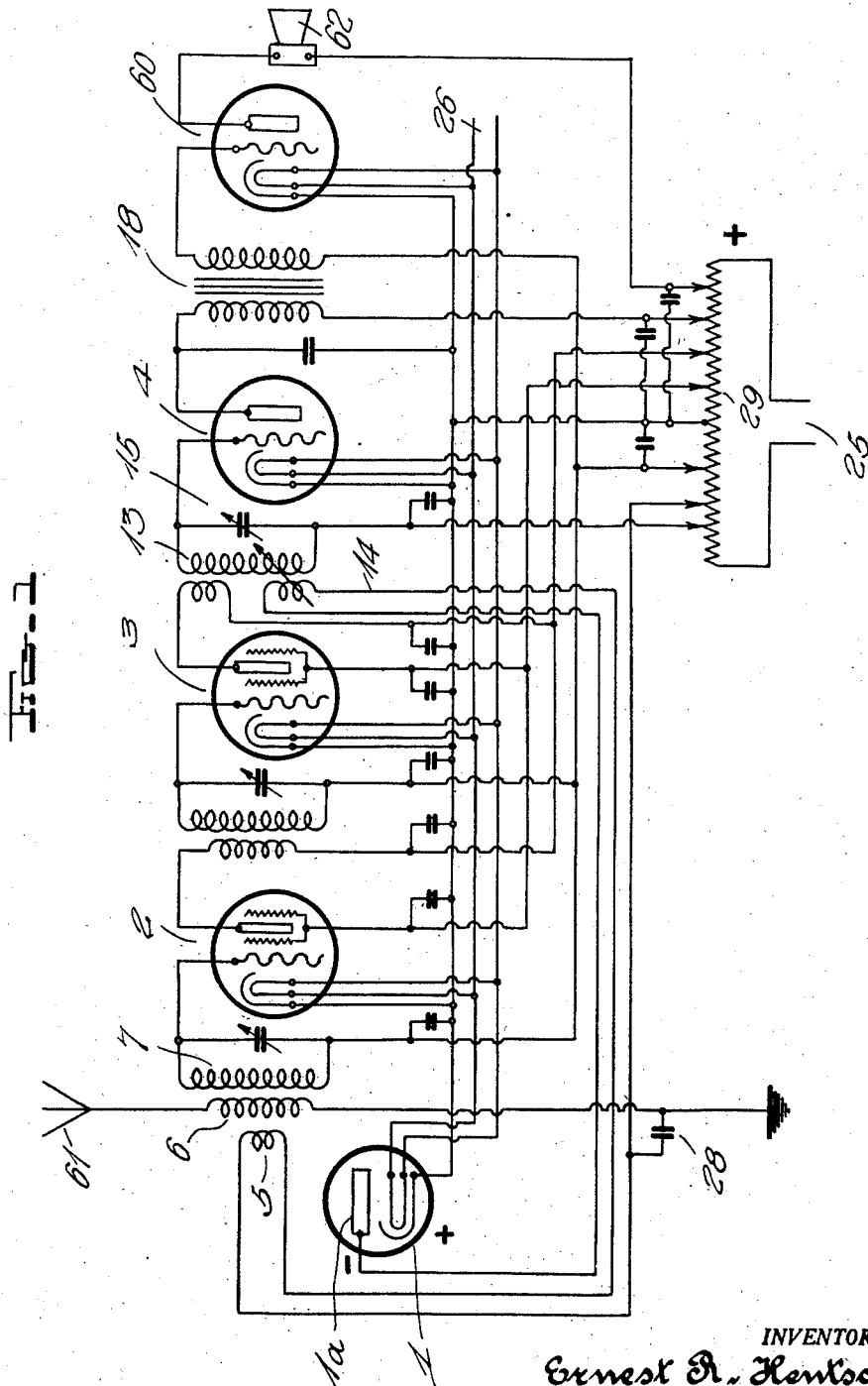
E. R. HENTSCHEL

1,884,681

VOLUME CONTROL SYSTEM

Filed July 14, 1930

3 Sheets-Sheet 1



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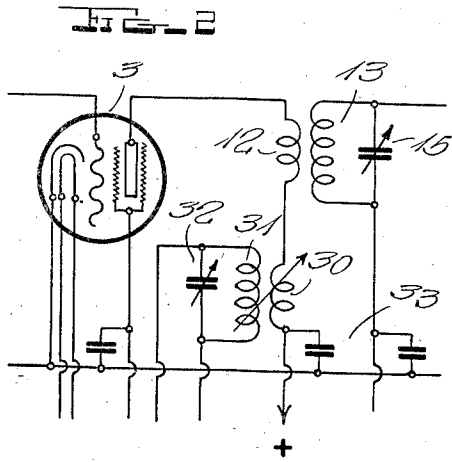
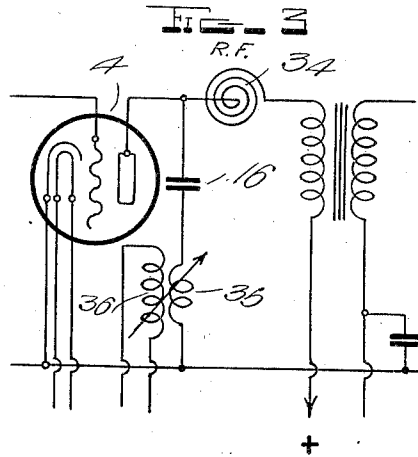
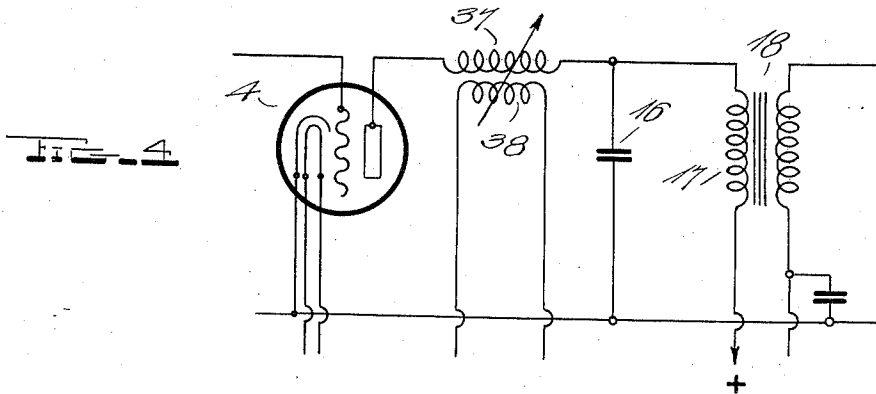
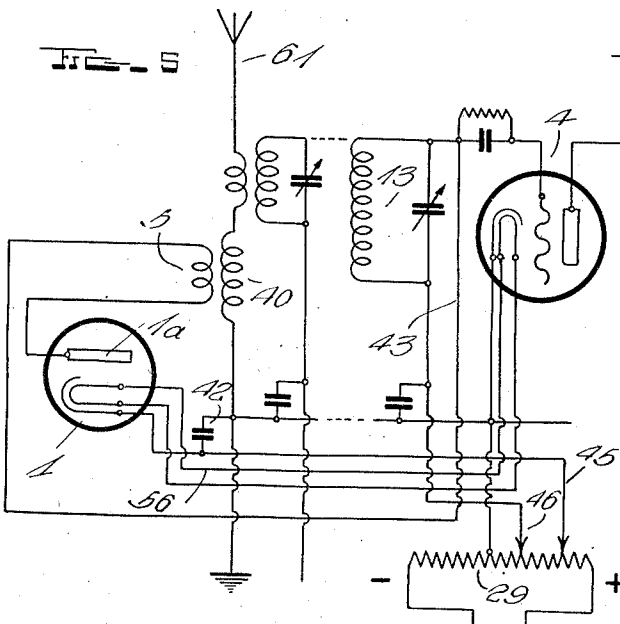
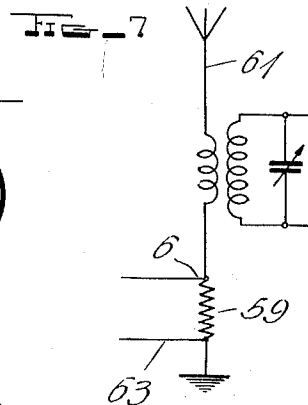
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VOLUME CONTROL SYSTEM

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3 Sheets-Sheet 2



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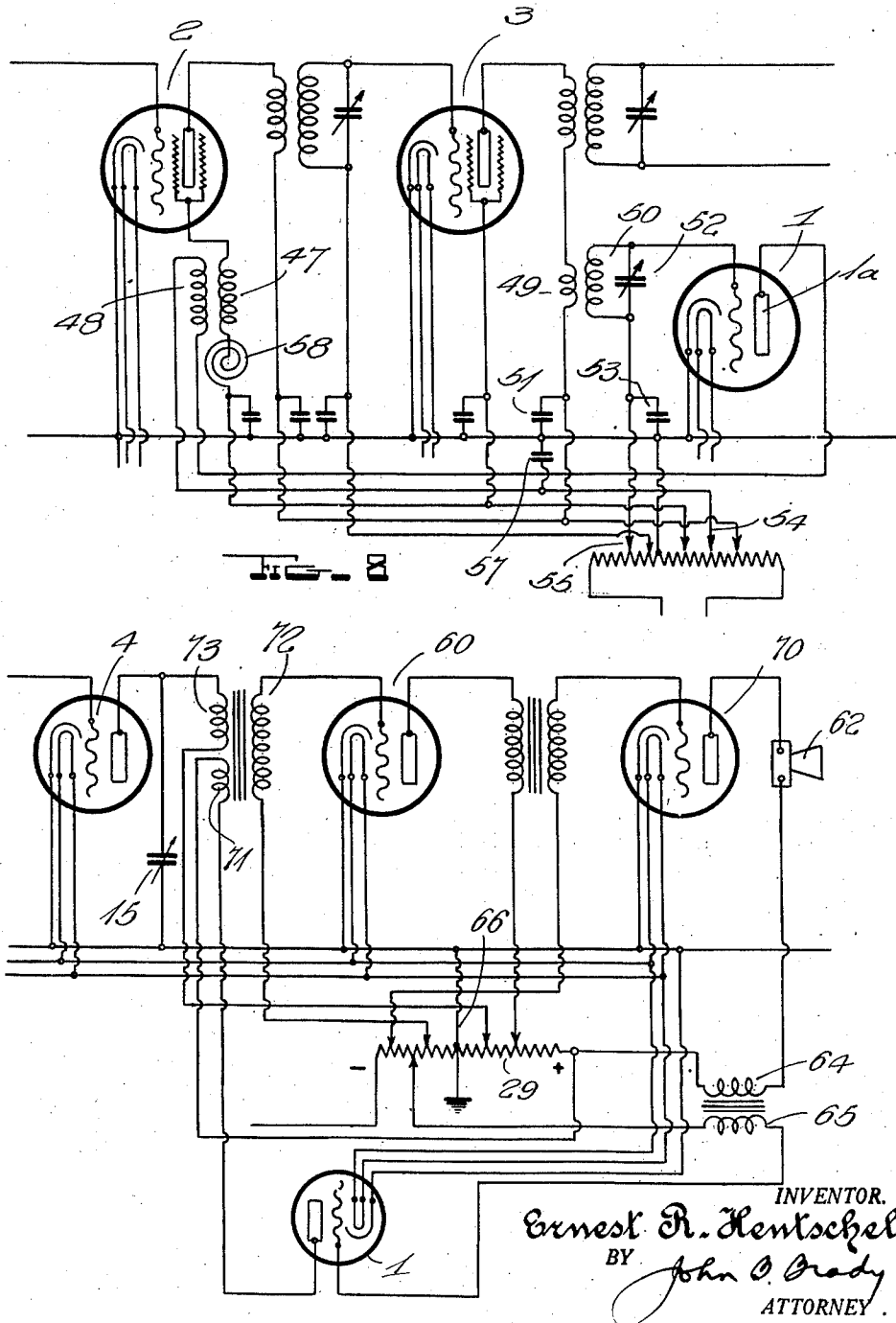
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3 Sheets-Sheet 3

FIG. 6



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UNITED STATES PATENT OFFICE

ERNEST R. HENTSCHEL, OF WASHINGTON, DISTRICT OF COLUMBIA; JOHN OLSON, ADMINISTRATOR OF SAID ERNEST R. HENTSCHEL, DECEASED, ASSIGNOR TO WIRED RADIO, INC., OF NEW YORK, N. Y., A CORPORATION OF DELAWARE

VOLUME CONTROL SYSTEM

Application filed July 14, 1930. Serial No. 467,942.

My invention relates broadly to volume control systems and more particularly to a circuit arrangement for a broadcast receiver having means for automatically opposing increases in amplitude of the signaling energy.

One of the objects of my invention is to provide means for impressing variable current upon the input system of the radio frequency amplifier of a radio broadcast receiver opposite in phase to the incoming signaling energy and proportioned in amplitude to the amplitude of the incoming signaling energy.

Another object of my invention is to provide means for automatically controlling the volume of sound reproduced by a broadcast receiver by impressing upon the circuits of the amplification system in the receiver energy in phase opposition to the incoming signaling energy for opposing increase in amplitude of the incoming signaling energy due to fading effects.

Still another object of my invention is to provide an arrangement of rectifier circuit associated with the radio frequency amplification system of a broadcast receiver and energized from a succeeding circuit of the broadcast receiver for impressing upon the preceding circuit current in phase opposition to the incoming signaling current to oppose any tendency of increase in signal amplitude under conditions of fading.

A further object of my invention is to provide a method for automatically controlling the volume or amplitude of signal energy in a radio receiver or similar device by taking energy from some portion of the radio frequency circuit when that energy exceeds a predetermined value, and feeding this energy into a preceding part of the circuit in phase opposition to the received energy.

Other and further objects of my invention will be understood from the specification hereinafter following by reference to the accompanying drawings, in which:

Figure 1 illustrates a circuit arrangement for a radio broadcast receiver embodying the principles of my invention; Fig. 2 illustrates a modified circuit arrangement for one stage of radio frequency amplification showing the means for distributing a portion of the in-

coming signaling energy to the rectifier control circuit of the volume control circuit of my invention; Fig. 3 illustrates an arrangement of detector circuit having means for impressing energy representing the radio frequency component of the received signal upon the control circuit to the rectifier illustrated in Fig. 1; Fig. 4 shows a further modification of the detector circuit which may be employed according to the principles of my invention; Fig. 5 illustrates a method of connecting the control rectifier for the volume control circuit in parallel with the input circuit of the detector for effecting volume control in the receiving system; Fig. 6 illustrates a circuit arrangement for impressing control current from a succeeding portion of the receiving circuit to a preceding portion thereof through the shield grid circuit of one of the preceding amplifier stages; Fig. 7 illustrates a modified form of connection between the control rectifier and the antenna circuit of a radio broadcast receiver; and Fig. 8 shows the application of my invention to the audio frequency amplifier circuits of a broadcast receiver.

My invention provides means for distributing current from a portion of the amplification circuit of a radio broadcast receiver whenever the amplitude of the incoming signaling energy exceeds a predetermined value and impressing such current upon a preceding portion of the amplification circuit in phase opposition to the phase of the incoming signaling current. Under conditions of fading, the signaling current may rise and fall in amplitude giving undesirable operation of the sound reproducing system and interfering with the enjoyment of the radio broadcast program. Such fading conditions are apparent in long distance broadcast reception where an incoming program may be lost in part while other parts of the program may be received with such amplitude as to be unbearable to the average listener and to overload the average loud speaker. By means of the circuit arrangement of my invention, the volume of reproduced sound is maintained at substantially constant amplitude. I provide a rectifier control circuit

which is coupled to a selected portion of the amplification system for introducing into the amplification system current in phase opposition derived from a succeeding portion of the amplification circuit for opposing the effects of the incoming signaling energy when such signaling energy increases in amplitude beyond a predetermined value. The principles of my invention may be carried out by a variety of different circuits, some of which I have illustrated in the accompanying drawings.

In Fig. 1 is shown one of the arrangements which have been reduced to practice. The radio receiver is diagrammatically illustrated as comprising radio frequency amplifier stages 2 and 3, a detector tube 4, and audio frequency amplifier 60. The input circuit of the radio frequency amplifier connects to antenna system 61 through a coupling system having primary winding 6 and inductively coupled windings 5 and 7. Conductors 26 represent the busses through which alternating current is conveyed to the filaments of the tubes, and 25 represents a voltage supply for the plates and grids of the several tubes, usually a rectifier and filter energized from rectified alternating current. Tube 4 is a detector of the plate rectification type. Inductance 13 and condenser 15 provide a tuned input circuit to the detector 4. Coupled to coil 13 there is provided a coil 14 which is connected in series with coil 5, tube 1, and a portion of resistance 29. Coil 5 is coupled to antenna coil 6 and tuned coil 7. Tube 1 is a rectifier. The function of the part of resistance 29 included in the circuit is to place a steady negative potential on the anode 1a of tube 1 so that there will be no flow of electrons from the cathode until the peak radio frequency voltage between cathode and anode exceeds a predetermined value. This radio frequency voltage is obtained through coil 14 and coil 13, and the voltage at which tube 1 is to pass current is determined by the amplitude of signal desired in the detector tube 4. The desired amplitude is customarily determined by listening to the output of the receiver through loud speaker 62. Tube 1 is biased so that it begins to operate at practically any desired amplitude of detector input voltage. Before the radio frequency voltage reaches this chosen value, there will be no current in tube 1, coil 5, or coil 14, but when this value is exceeded there will be one pulse of current at every cycle. Coil 5 is coupled to coil 6 so that the instantaneous values of currents will be in phase opposition, so that when current begins to flow in coil 5 the energy input to the receiver is decreased. Condenser 28 is placed in the circuit as shown so that the radio frequency current will not need to pass through resistor 29.

As the current in the antenna 61 is small compared to that in coil 13 any tendency for

the antenna current to increase will produce a large increase in the bucking current in coil 5, so that the energy input to the receiver is instantaneously reduced to that value at which rectifier 1 just begins to pass current.

As no energy is drawn from coil 14 when its voltage is lower than that required for the operation of tube 1, the volume control apparatus does not interfere with the reception of weak signals. The coupling between coils 14 and 13 is made variable which provides a method of varying the radio frequency voltage applied across tube 1, which gives another method of regulating the amplitude of signal at which the automatic control becomes effective.

There are many methods of tapping sources of this bucking current and many methods for feeding this bucking current into another part of the circuit. Figs. 2 to 8 show several modified circuit arrangements which may be used. In each figure only a fragmentary part of the radio receiving circuit is shown. In all the illustrations, including Fig. 1, the same reference numbers refer to corresponding parts.

In Fig. 2, I have shown a method of tapping energy from the plate circuit of tube 3 in such manner that coil 31 does not appreciably rob coil 13, nor affect its tuning. As the plate resistance of a shield grid tube is high, the external impedance seldom matches it, so this additional impedance supplied by coil 30 and its coupled circuits may even increase the efficiency and cause the tube to give better amplification, which will be beneficial. Coil 31 may be tuned by condenser 32 if voltage amplification is needed. The two ends of the coil 31 are connected to tube 1 and coil 5 as in Fig. 1. 33 represents the usual by-pass condenser. Condenser 32 may be one of a gang of condensers, or it may be tuned separately, thereby giving another means of regulating the voltage on tube number 1.

Fig. 3 shows a method of using the radio frequency current in the plate circuit of detector tube 4, thus obtaining one more stage of amplification for the volume control apparatus and eliminating any danger of this apparatus affecting the tuning of the radio frequency stages. 34 is a radio frequency choke coil which forces most of the radio frequency current to flow through blocking condenser 16 and coil 35 to ground. Coil 36 is coupled to coil 35 and its two ends are connected as previously described with reference to coils 14 and 31 in Figs. 1 and 2. Coil 36 may be tuned with a condenser but this greatly increases the effective impedance of coil 35, so it is preferable to operate it as shown because path 16 and 35 must be a low impedance path to ground.

Fig. 4 shows a modified form of control circuit wherein the primary winding 37 of a

transformer is directly connected in the plate lead of the detector tube 4 between the plate of the tube and the primary winding 17 of audio frequency transformer 18.

Fig. 5 shows a method of directly tapping the input circuit of detector tube 4 and also another method of feeding the bucking current into the antenna 61. It is not necessary to use these two methods together; any one of the methods here described of obtaining bucking current may be used with any of the methods for feeding this current into another part of the circuit. In this figure, the energy is taken directly from the ends of coil 13. Wire 43 leads from this coil through coil 5 to the anode 1a of two element tube 1. The cathode of this tube is connected through wire 45, a portion resistance 29, and wire 46 to the other end of coil 13. Tube 1 and coil 5 act as previously described, except that coil 5 is coupled to a separate coil 40 in the antenna circuit, and induces in this coil an E. M. F. which opposes the antenna current. Condenser 42 is a by-pass for radio frequency current. Wires 45 and 46 tap resistor 29 at such points that the anode of tube 1 is at a negative potential with respect to the cathode for the reason previously explained. Coil 5, instead of being in the position shown, could be inserted at point 56 in the wire connected to the cathode of tube 1, and coupled to coil 40 as shown.

Fig. 6 illustrates a three element rectifier and another method of feeding the bucking current into the circuit. Coil 49 feeds radio frequency energy into coil 50 which may be tuned by condenser 52 as shown. The grid is biased by moving contact 55 so that no plate current flows until the radio frequency pulsations in coil 50 exceed a predetermined value. When this value is exceeded then there are, in the plate circuit, pulsations of current at radio frequency which may be used as previously described for bucking the energy in any preceding part of the circuit. 51, 53 and 57 represent by-pass condensers, and wire 54 taps resistance 29 at the point which gives the proper plate voltage for tube 1a.

There is illustrated here another method of feeding the bucking current into the circuit. The current in coil 48 induces an E. M. F. in coil 47 which is in the shield grid line of tube 2, thereby causing fluctuations in the shield grid potential. Coils 48 and 47 are to be so coupled that the pulsations of E. M. F. on the shield grid are in such time phase as to directly oppose the pulsations on the control grid, and thereby reduce the radio frequency energy in the plate circuit. A small choke coil 58 may be inserted as shown if it is found that there is insufficient energy supplied the shield grid, so as to prevent loss to ground.

This bucking energy may also be intro-

duced in a similar manner in the control grid lead or the plate lead. Also, instead of introducing the energy through a transformer, it may be introduced directly into various parts of the circuit across an impedance. Fig. 7 illustrates such a connection where wires 6 and 63 lead to the source of bucking current which flows through resistance 59 setting up an E. M. F. which opposes the antenna E. M. F. Resistance 59 may be replaced by an inductance or a capacity. Instead of employing the half wave rectifier shown at 1a, full wave rectifier may be used.

My invention is also applicable to the audio frequency amplification portion of the broadcast receiver as illustrated in Fig. 8. I have illustrated the detector at 4 associated with the audio frequency power amplifier tubes 60 and 70. Increases in volume of reproduced sound in the loud speaker 62 are accompanied by increases in amplitude of the audio frequency current in the output circuit of power amplifier tube 70, thereby increasing the current through the primary winding 64, which energy is inductively transferred to the secondary winding 65 and applied to the control circuit of rectifier tube 1. The anode circuit of rectifier tube 1 connects through winding 71 returning to the potential source across potentiometer 29 returning through the tap 66 to the cathode circuit. As the rectifier 1 is excited, a bucking E. M. F. is set up in winding 71 tending to oppose signaling energy in winding 72 which is transferred thereto from winding 73.

The operation of the automatic system of my invention depends upon the amplitude of the carrier wave and as the amplitude increases the opposition effect introduced into the signal receiving circuits correspondingly increases, thereby restoring the operation of the circuits to normal condition. I have found the circuit arrangement of my invention practical in its construction and successful in its operation and while I have shown a number of embodiments of my invention, I desire that it be understood that modifications may be made and that no limitations upon my invention are intended other than are imposed by the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is as follows:

1. In a signal receiving system, a multiplicity of electron tube amplification stages, and means coupling one amplification stage with a preceding amplification stage for feeding back energy to said preceding amplification stage in phase opposition to the incoming signaling energy in proportion to the amplitude of the incoming signaling energy.

2. A signal receiving system comprising

a multiplicity of amplification stages, and means coupling a portion of one amplification stage with a portion of a preceding amplification stage for impressing energy thereon in 180° phase displacement with respect to incoming signaling energy in said preceding amplification stage for regulating the amount of energy in said signal receiving system.

3. In a signal receiving circuit, an amplification system including a multiplicity of intercoupled electron tube stages, a circuit extending between a portion of one electron tube stage and a portion of a preceding electron tube stage for transferring current from the succeeding amplification stage to the preceding amplification stage, and means in said circuit for displacing the phase of the current thus transferred with respect to the phase of signaling current in said preceding amplification stage, whereby the effects of increases in amplitude of incoming signaling energy are automatically opposed in proportion to the amount of energy received.

4. A radio broadcast receiver comprising an amplification system including a multiplicity of intercoupled electron tube amplification stage with the circuit of a preceding portion of the circuit of one electron tube amplification stage with the circuit of a preceding electron tube amplification stage for transferring current therebetween, and means for displacing the phase of the current thus transferred with respect to the phase of incoming signaling current in said preceding amplification stage for opposing increases in amplitude of the incoming signaling current for maintaining the amount of energy in said amplification stages at a constant value.

5. A radio receiving system comprising an amplification system including a multiplicity of electron tube amplification stages; a circuit coupling a portion of one electron tube amplification stage with a portion of a preceding electron tube amplification stage, and a rectifier disposed in said circuit for rendering effective upon said preceding amplification stage current impulses opposed in phase to the phase of the incoming signaling currents in said preceding electron tube amplification stage for variably controlling the amplitude of the signaling energy transferred through said amplification system for maintaining the amplitude of signaling energy delivered by the output of said amplification stages substantially constant.

6. A radio broadcast receiver comprising an amplification system including a multiplicity of intercoupled electron tube amplification stages, means intercoupling a portion of the circuit of one electron tube amplification stage with the circuit of a preceding electron tube amplification stage for transferring current therebetween, and a rectifier disposed

in circuit with said means, said rectifier having its input circuit excited by energy received from said succeeding amplification stage and adapted to deliver current impulses from the output circuit thereof to said preceding amplification stage in phase opposition to the current impulses derived from the incoming signaling energy, the opposition effect being variably controlled according to the amplitude of the incoming signaling energy for maintaining the amplitude of signaling energy delivered by said amplification system substantially constant.

7. In a radio receiving system, an amplification circuit including a multiplicity of electron tube interconnected amplification stages, a circuit intercoupling a succeeding amplification stage with a preceding amplification stage, said circuit including a rectifier having its input circuit excited by energy derived from said succeeding amplification stage and having its output circuit connected to deliver current impulses to said preceding amplification stage in phase opposition to the phase of the incoming signaling energy, and means for controlling the amplitude of energy delivered from said succeeding amplification stage to the input circuit of said rectifier, whereby increases in signal amplitude beyond a predetermined limit introduces opposition effects between the current impulses delivered by said rectifier and the incoming signaling energy.

In testimony whereof I affix my signature,
ERNEST R. HENTSCHEL.

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