Dec. 17, 1935. G. R. EATON 2,024,152

RECEIVING SYSTEM

Filed Nov. 29, 1929 2 Sheets-Sheet 1

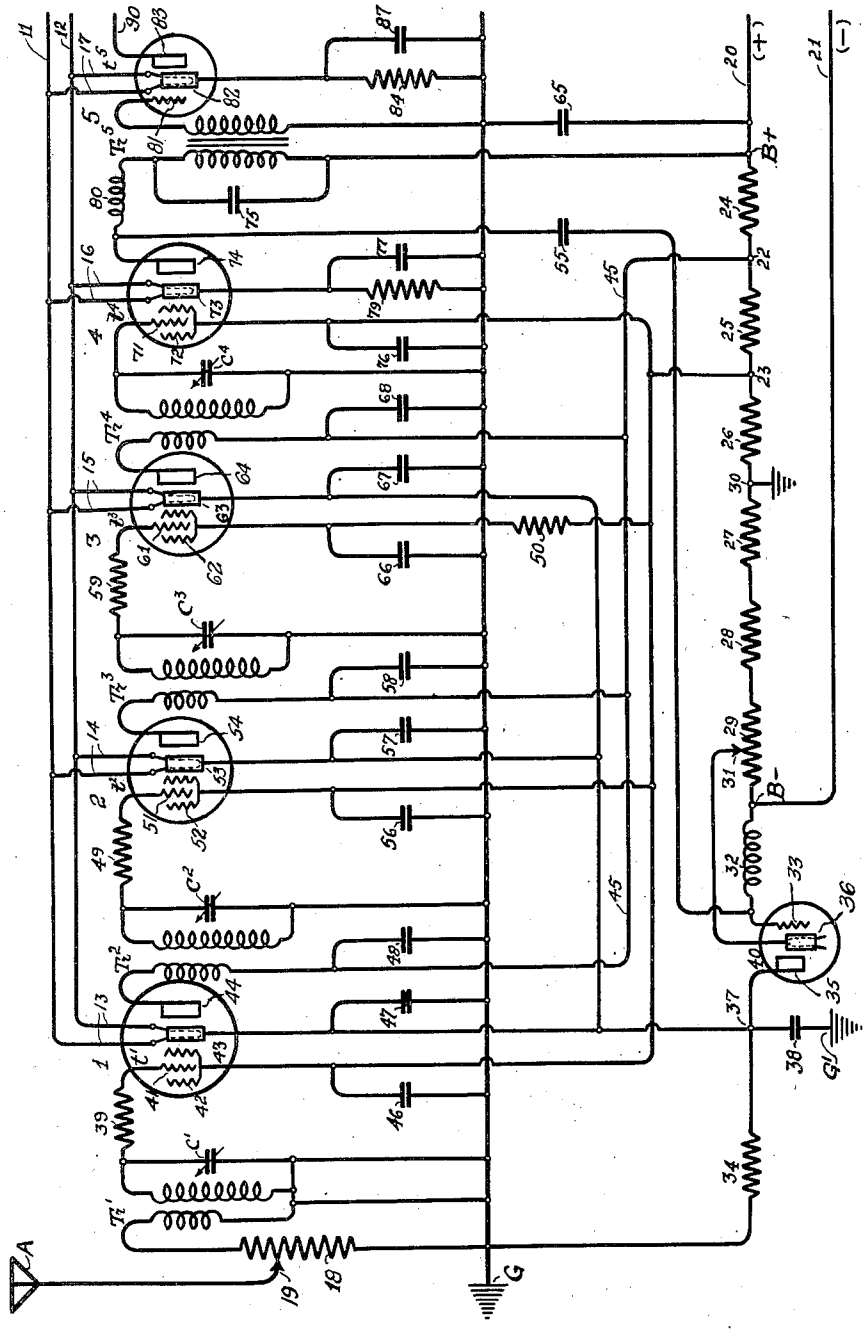

Fig. 1.

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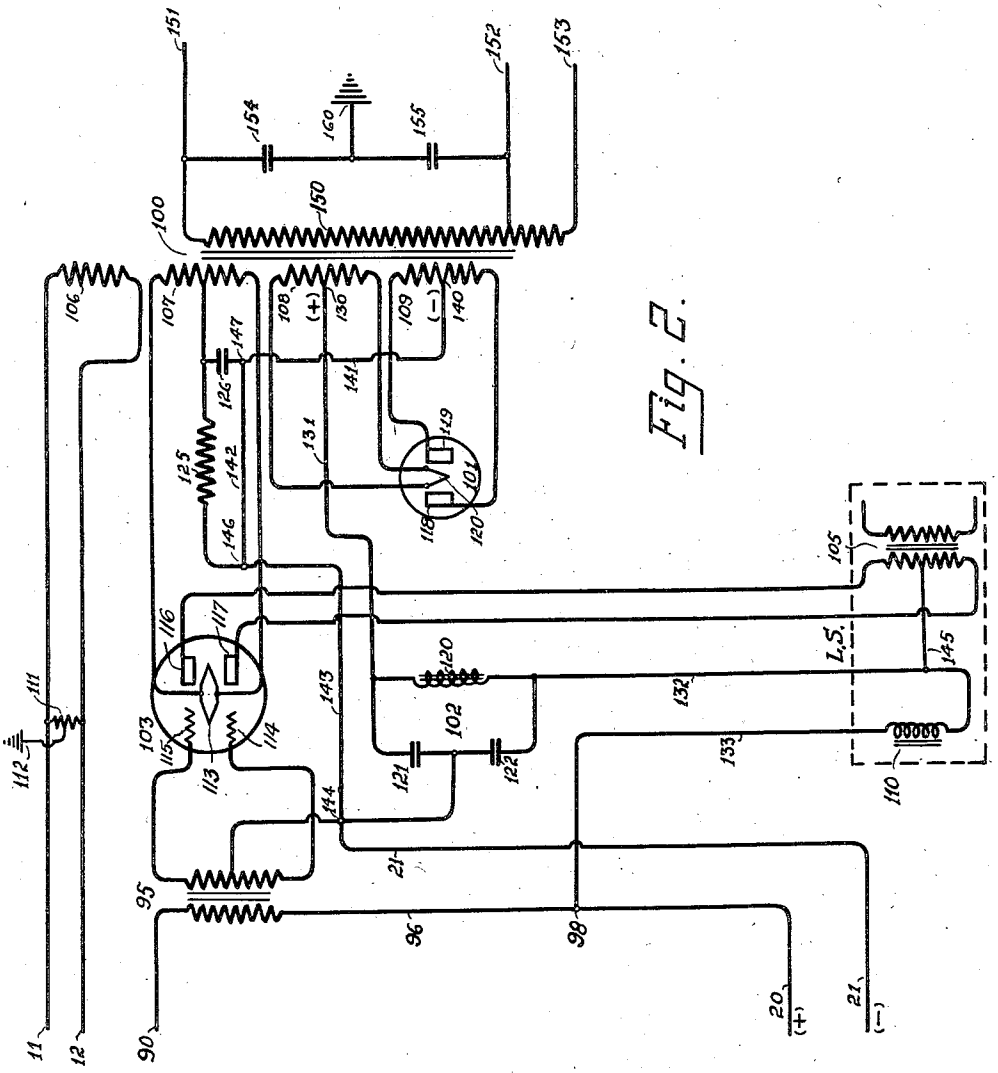

Fig. 2.

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2,024,152

RECEIVING SYSTEM

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3 Claims. (Cl. 250—20)

My invention relates to radio receiving circuits, and more particularly to a radio signal amplification system in combination with a source of rectified alternating current, and an object of my invention is to provide an improved circuit arrangement for amplifying signal modulated electric waves.

A feature of my invention is the provision of an improved automatic volume control device adapted to maintain automatically the output strength of the received signals to a certain predetermined value for input signals of different strengths.

Another feature of my invention is the provision of an audion tube as a part of the volume control device, the grid of said audion tube being associated on one side with the anode of the detector tube, on the other side through an inductive impedance with the negative terminal of the power supply circuit for the purpose of preventing grid rectification in said audion tube.

A still further feature of my invention is the provision of a choke coil in the output circuit of the detector tube for the purpose of deflecting the radio frequencies of the signal into the grid circuit of the audion tube associated with the volume control.

For a better understanding of my invention reference may be had to the following description in connection with the accompanying drawings in which:

Fig. 1 is a diagrammatic representation of the receiving set circuits;

Fig. 2 illustrates diagrammatically an alternating current rectifying and power supply unit together with a loud speaker circuit both intended to be used in combination with the receiving set as illustrated in Fig. 1.

Referring now more in detail to Fig. 1, it will be noted that I have shown a radio signal receiving system comprising three high frequency amplifying stages connected in cascade and designated respectively as **1**, **2**, and **3**, one detector stage designated as **4** and one low frequency amplifying stage designated as **5**. The three thermionic tubes of the first three stages designated respectively as t', t^2, and t^3 as well as the detector tube designated as t^4 belong to the type having a screen grid and equi-potential alternating current heated cathode. Tube t^5 of the audiofrequency stage differs from those of the preceding stages by the fact that it has no grid screen. Alternating current for heating the cathodes is supplied to the tubes by the parallel circuit **13**, **14**, **15**, **16**, and **17** branching off the buss bars **11** and **12**, said buss bars originating in the power supply unit as illustrated in Fig. 2. Direct current for the space discharge and for the appropriate polarizing of the control electrodes, the grid screens and the cathodes of the tubes is supplied to the set by the buss bars **20** and **21** in a manner to be subsequently described more in detail. The buss bars **20** and **21** form the continuation of similarly designated buss bars in Fig. 2.

Each of the high frequency amplifying stages **1**, **2**, and **3** and the detector stage **4** is provided with an individual air core coupling transformer designated respectively as Tr', Tr^2, Tr^3, and Tr^4. The low frequency stage **5** is coupled to the detector stage by the iron core audio transformer Tr^5. Each of the secondary windings of transformers Tr', Tr^2, Tr^3, and Tr^4 are shunted by variable condensers C', C^2, C^3, and C^4 respectively for the purpose of forming resonant circuits therewith. These condensers are multiple or gang controlled for the purpose of tuning to the wave length of the incoming signal.

Coming now to the manner in which direct current of the requisite potentials is supplied to the various audion tubes it will be noted that the buss bars **20** and **21** are bridged between terminals B+ and B— by a resistance strip comprising resistances **24**, **25**, **26**, **27**, **28**, and **29** in series. The fact that an intermediate point between resistances **26** and **27** is grounded renders the terminal B— negative with respect to ground. It will be noted that resistance **29** is connected to ground also by a branch circuit comprising slide contact **31**, audion tube **40**, and resistance **34**. The operation of this circuit in connection with the volume control arrangement will be explained hereinafter.

It is obvious that from the resistance strip between the terminals B+ and B— we can obtain various potentials as desired depending upon the intermediate points tapped. For instance, it will be noted that direct current potential for energizing the anodes **44**, **54**, and **64** of tubes t', t^2, and t^3 of the high frequency amplifier is obtained from a common tap **22** on the positive side of the resistance strip through the medium of lead **45** common to the plate circuits of all three tubes. The cathodes of these three tubes, on the other hand are linked to ground through a common biasing resistance **34**, which as has been noted, is included also in the volume control circuit.

The anode **74** of the detector tube t^4 is energized from the positive buss bar **20**. This is also

the case with the anode of the low frequency amplifier tube t^5, the corresponding circuit comprising the anode **83**, lead **90** continued in Fig. 2, primary winding of transformer **95**, lead **96**, and tap **98** common also to the positive buss bar **20**.

For the purpose of reducing the internal capacity of tubes t', t^2, and t^4 to a minimum their respective grid screens **42**, **52** and **72** are polarized from a common tap **23** on the positive side of the resistance strip. This is also the case with the grid screen **62** of tube t^3, except that a resistance **50** is interposed between common tap **23** and said grid screen **62**. Condensers **46**, **56**, **66** and **76** linking the grid screens of tubes t', t^2, t^3, and t^4 to ground supply a low impedance by-pass to undesirable regenerative high frequency currents. Condensers **47**, **57**, **67**, **77**, and **87** linking the cathodes of each of the tubes shown in the drawings to ground serve as low impedance links in the input and output circuits. Condensers **48**, **58**, and **68** linking the winding of the coupling transformers Tr', Tr^2, Tr^3 fulfill the double role of links in the respective output circuits and of by-pass condensers for undesirable stray frequencies. Resistances **39**, **49**, and **59** incorporated in the grid circuits of the high frequency amplifier tubes serve as stabilizers, by reducing undesirable regenerative feed-back from the plate circuit into the grid circuits.

As the method of operation of a cascade connected amplifier is well known, we shall not enlarge upon it except to state in a general way that the signal after being picked up by the antenna A is transmitted in the usual manner through the instrumentality of transformer Tr' and the resonant circuit connected therewith to the grid **41** of the first radio frequency amplifier tube t', in which tube it is magnified and transmitted in a similar manner to the grid **51** of second high frequency amplifier tube t^2, where it is magnified again and similarly transmitted to the grid **61** of the last high frequency amplifier tube t^3. After further amplification in tube t^3 the signal high frequencies are communicated to the grid **71** of the detector tube, where upon rectification the high frequencies are transformed into low frequencies and transmitted as such through the instrumentality of audio transformer Tr^5 consecutively to the grid and plate circuits of audiofrequency amplifier tube t^5. The further destination of the signal will be ascertained when we come to describe the power supply circuit as represented on Fig. 2.

Turning now to the volume control arrangement, it has been noted that the cathode **36** of volume control tube **40** is linked to resistance **29** on the negative side of the resistance strip through slide contact **31** while the anode **35** is linked to ground through biasing resistance **34** common to the biasing circuits of the high frequency amplifier tubes t', t^2, and t^3. At the same time the grid **33** is linked on one side through inductive impedance **32** to the negative terminal B—, and on the other side through condenser **55** to the anode of the detector tube t^4. By virtue of the said connection of the anode to ground which is positive with respect to the negative side of the resistance strip from which the cathode derives its potential, a plate discharge is established in the tube.

The inductive impedance **32** in combination with resistance **29** is proportioned in such a manner as to bring the operating point of tube **40** to the lower bend of its static characteristic curve, where, as well known, it will operate as a rectifier, providing plate rectification. Since the biasing resistance **34** is traversed by the plate current of tube **40**, it is obvious that the greater said plate current, the larger will be the voltage drop in resistance **34**, and consequently the larger the grid bias of tubes t', t^2, t^3 and the smaller the amplitude of the signal frequencies.

By varying the plate current of tube **40** we can regulate the amplitudes of the signal frequencies. The plate current of tube **40** can be varied in my arrangement by varying the grid bias, the corresponding biasing circuit comprising the grid **33**, inductive impedance **32**, part of resistance **29**, and cathode **36**. There are two ways of varying the grid bias of tube **40** in my arrangement, one is manual the other is automatic. The first is attained by varying through slide contact **31** the portion of resistance **29** included in the biasing circuit of tube **40**. The second is performed by the condenser **55** linking the grid **33** with the anode **74** of the detector tube.

The space discharge of the detector tube as well known will have impressed upon it both audiofrequncies and radio frequencies, the first will pass through the primary of audio transformer Tr^5, while the second will be partly shunted by condenser **75**, and in part will be forced in my arrangement by the radio frequency choke coil **80**, provided for that purpose, into the path of condenser **55** and grid **33** of the volume control tube **40**. Since volume control tube **40** operates to furnish plate rectification, it is evident that an increase of the amplitude of the radio frequencies passing through the detector tube will be communicated through the condenser **55** to the grid **33** of the volume control tube as increased potential variations thus acting in the well known manner to increase the plate current of the volume control tube **40**, which in turn will result in a reduced amplification in the high frequency amplifier tubes as previously explained.

Naturally, the reverse result would be obtained when the amplitude of the radio frequencies drops below its normal or desired value. The desired value of amplification is predetermined as readily perceived by the position of slide contact **31** or resistance **24**, which position imparts a basic bias to the grid **33** of tube **40**.

The purpose of linking grid **33** to the negative terminal B— by an inductive impedance **32** instead of by a grid leak resistance, is to prevent an accumulation of electrons on grid **33** which would cause grid rectification.

The need for an automatic volume control arises most commonly in connection with the tuning operation when switching from one transmitting station to another. The fact that some of these stations are either located nearer to the receiver or more powerful than others, would result in a variable output volume of the receiver if it were not for the action of the automatic volume control. Naturally the volume control as described would also operate to keep the signals from the same station within a predetermined volume.

Condenser **38** linking the anode of volume control tube **40** to ground at G' functions in conjunction with condenser **47** of the first amplifier stage to prevent undesirable regenerative energy from the second and third high frequency amplifier stages reaching the tube t' of the first stage. Condenser **65** linking the positive buss bar **20** to ground besides serving as a link in the output circuits of tubes t^4 and t^5, prevents ripples due to the alternating current of the supply source from

impressing themselves upon the amplifier circuits.

Referring now to the power supply unit as represented diagrammatically in Fig. 2, it will be noted that it comprises in the main a power transformer 100, a rectifier tube 101, a filter 102, and a push-pull amplifier tube 103 having an input transformer 95 and an output transformer 105, the latter incorporated with the loud speaker unit L.S. whose electrical connections are shown diagrammatically at the bottom of the figure. The secondary winding of power transformer 100 comprises four independent coils 106, 107, 108, and 109. Of these 106 supplies alternating current for the heating filaments of the amplifier tubes t', t^2, t^3, t^4, and t^5 and of the volume control tube 40 in Fig. 1 through the already referred to buss bars 11 and 12. At a convenient point the buss bars 11 and 12 are bridged by a resistance 111 having its mid-point connected to ground at 112 for the purpose of eliminating ripples due to the alternating current of the supply source and to high frequency currents.

Coil 107 supplies the filaments 113 of the push-pull amplifier tubes 103; coil 108 supplies the filament 120 of the rectifier tube 101, and coil 109 supplies the plates 118 and 119 of the rectifier tube 101.

The positive terminal of the rectifier is the usual mid-point 130 of coil 108 supplying the filament 120, and the negative terminal 140 is identical with the mid-point of coil 109 supplying the plates 118 and 119 of the rectifier tube 101.

The supply of positive voltage to the receiving set can be traced from terminal 130, over lead 131, filter 102, lead 132, field coil of loud speaker 110, lead 133, to tap 98, from where it is delivered on one side to the anode of the last tube t^5 of the receiving set through lead 96, primary of transformer 95 and lead 90, and on the other side to the resistance strip of Fig. 1 by buss bar 20 common to Figs. 2 and 1.

The supply of negative voltage to the receiving set can be traced from terminal 140 of the rectifier, over leads 141, 142, 143, tap 144, buss bar 21 to the resistance strip of Fig. 1.

The filter 102 consists of the inductive impedance 120 incorporated in the positive supply line and the condensers 121 and 122 linking each end of impedance 120 to the negative supply line. The operation of this arrangement of impedance and capacities to reduce to uniformity the direct current in the respective supply lines is well known.

The push-pull amplifier 103 serves as a final amplifying stage while at the same time eliminating in the well known manner undesirable even harmonics.

For the purpose of imparting the proper potential gradient to the anodes of the push-pull amplifier tubes with respect to the cathodes, it will be noted that their anodes 116 and 117 communicate, with the positive terminal 130 of the rectifier through the primary winding of the output transformer 105, lead 145, lead 132, filter 102 and lead 131. The average potential of the cathodes 113, on the other hand, is brought down to the level of the negative terminal 140 of the rectifier by connecting the center tap of coil 107 supplying the cathodes 113 to the said negative terminal 140 through biasing resistance 125, tap 146, lead 142, tap 147, and lead 141. The elements just enumerated traced from cathode to anode form the output circuit of the push-pull amplifier tubes, except that condenser 126 should be substituted for biasing resistance 125.

We have traced so far the audiofrequencies of the signal to the plate circuit of the last amplifier tube t^5 in Fig. 1, said plate circuit comprising the anode 83, lead 90, common to Figs. 1 and 2, primary winding of transformer 95, lead 96, buss bar 20 common to Figs. 2 and 1 and condensers 65 and 85 to the cathode 82.

The audiofrequency signal oscillations passing through the primary winding of the input transformer 95 induce similar oscillations in the secondary winding from whence these are communicated to the grids 114 and 115 and magnified in the output circuit of the push-pull amplifier as traced. The magnified oscillations combine in the well known manner in the primary winding of the output transformer 105, eliminating even harmonics and inducing corresponding oscillations in the secondary winding from where the energy is transferred to the voice coil of a dynamic type of loud speaker, not shown in the figure, vibrating in a field generated by field coil 110.

The purpose of condenser 126 shunting the biasing resistance 135, has been partly indicated, namely, to supply a low impedance path in both the input and output circuits of the push-pull amplifier tubes.

The primary winding of transformer 100 is provided with three terminals 151, 152, and 153; of these 151 and 152 are designed to receive the commonly available alternating current voltage while 151 and 153 can be used in localities where the voltage is slightly higher. The condenser bridge between the terminals 151 and 152 consisting of condensers 154 and 155 intermediately grounded at 160 is designed to offer a low impedance path to any undesirable stray high frequencies which might have become introduced into the alternating current supply lines.

In general the operation of the system consists in tuning in the desired signal by rotating the gang condenser and then setting the automatic control device to the desired volume output.

If the volume input was to vary now, the automatic control tube increases or decreases the bias on the radio amplifier tubes to maintain the volume output constant. If the tuning device is now rotated to tune in another station the automatic volume control mechanism operates to control the radio amplifier to maintain the volume output constant. The manual volume control 19 associated with the antenna A is used if the set is situated near a powerful broadcasting station and it is desired to further reduce the volume output.

While I have shown certain specific circuit arrangements it is obvious that changes and modifications may be made without departing from the spirit of my invention, therefore, the invention should only be limited by the scope of the appended claims.

Having described my invention, what I claim as new and desire to secure by United States Letters Patent is:

1. An amplification system provided with audion tubes, a common power distribution circuit for said audion tubes, an auxiliary electron tube, some of said tubes having a common control grid biasing resistance forming part of the plate circuit of said auxiliary electron tube, a fixed inductive impedance, the control grid circuit of said electron tube linked to said distribution circuit by said fixed inductive impedance and to the anode of one of said audion tubes through a condenser and a variable manually controlled non-inductive impedance for the purpose of controlling

the plate current in said electron tube through control of its grid bias and thereby controlling the voltage drop in said common biasing resistance.

2. In an amplifier circuit including audion tubes as radio amplifier elements and an audion tube as a detector element, a common source of current for said tubes, means including an audion tube linking the anode of said detector tube to the control grid elements of some of said radio amplifier tubes and adapted to automatically vary the control grid bias of said amplifier tubes in proportion to the variation of the plate current of said detector tube, an inductive impedance connecting said common source of current to the grid element of said audion tube, a variable manually controlled resistance for controlling the volume of amplification of said audion tube through the control of the grid bias and the plate current of said electron tube.

3. In a receiving system including a plurality of cascade connected audion tubes, a source of current for said audion tubes, control grid biasing circuits for some of said audion tubes, a common resistance for said control grid biasing circuits, means including an audion tube linking the plate circuit for the detector tube to said control grid biasing circuits and adapted to automatically maintain the output of said audion tubes at a predetermined normal value, an inductive impedance connecting said source of current to the grid element of said audion tube, and a manually controlled resistance for predetermining said normal value by controlling the grid bias and the plate current of said electron tube.

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