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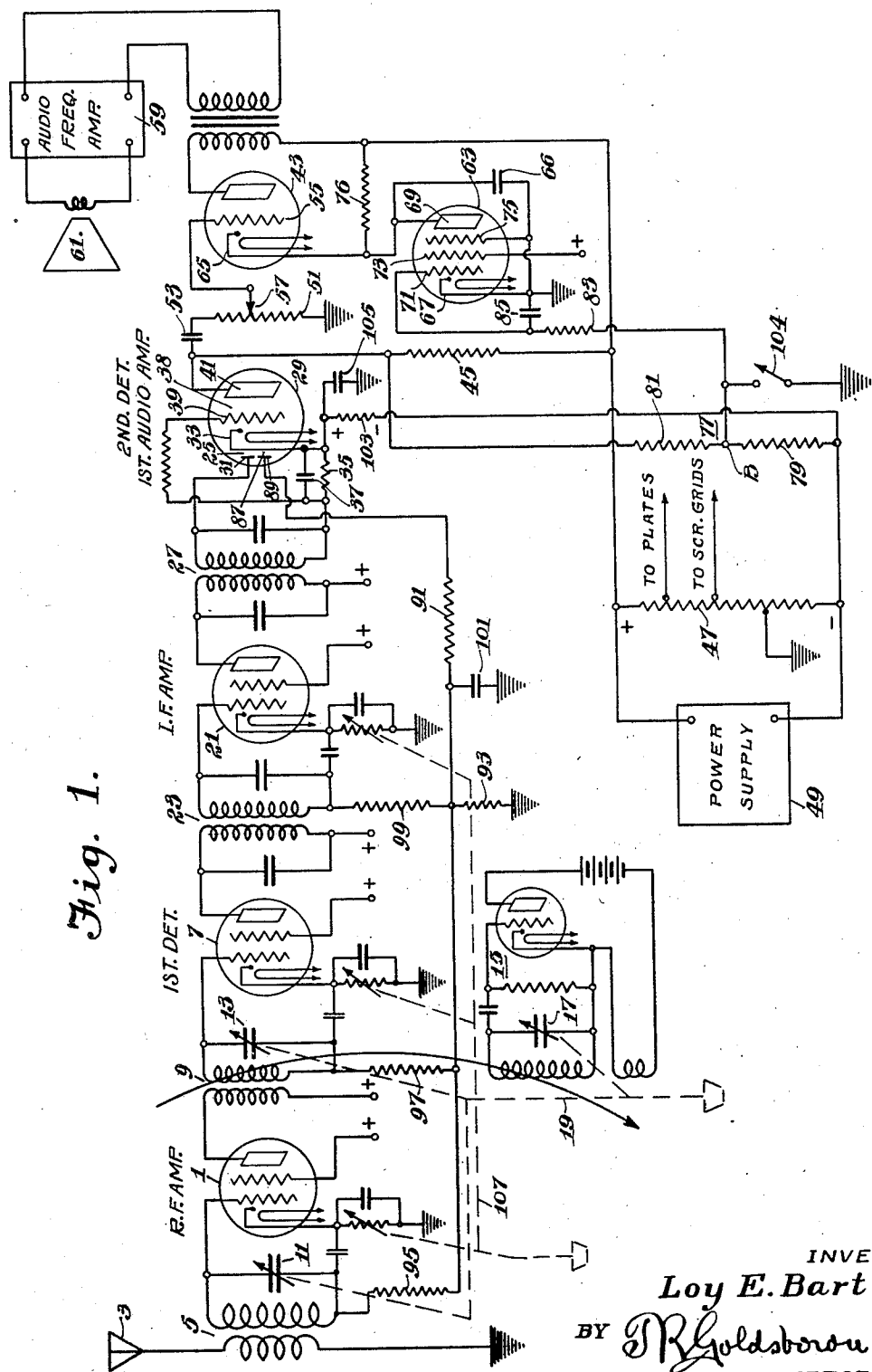
L. E. BARTON

2,028,859

RADIORECEIVER

Filed Nov. 25, 1933

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Fig. 3.

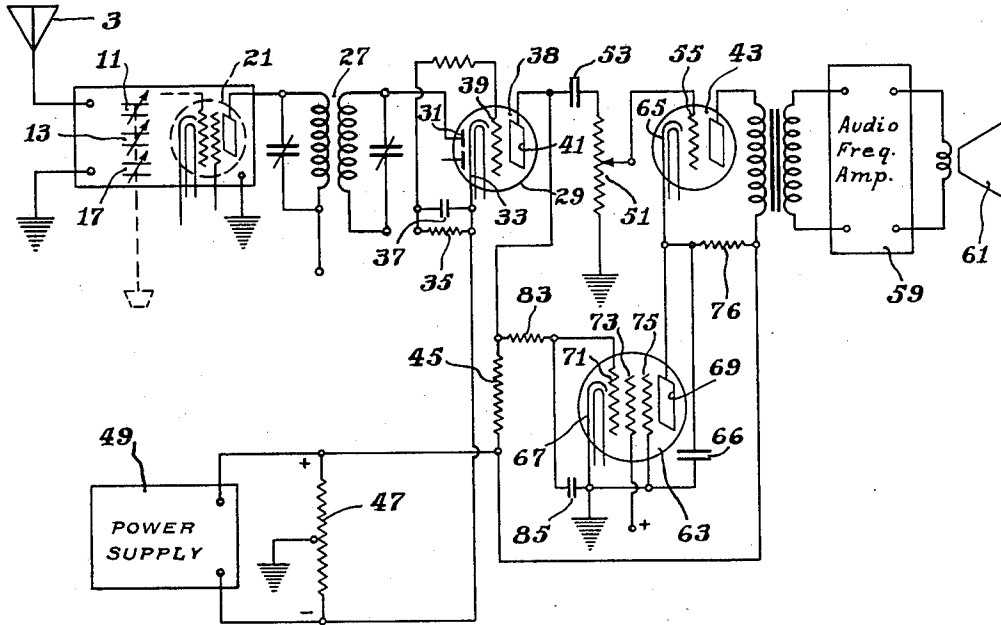
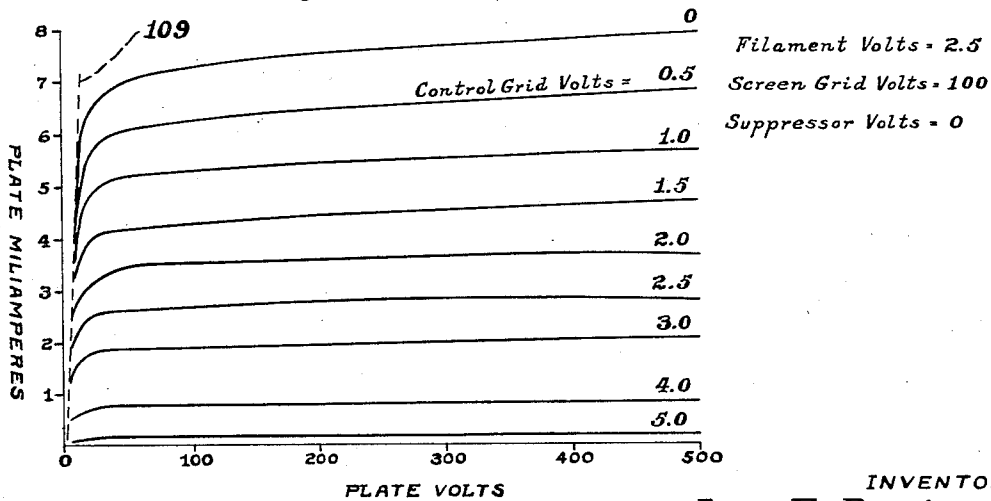


Fig. 2.



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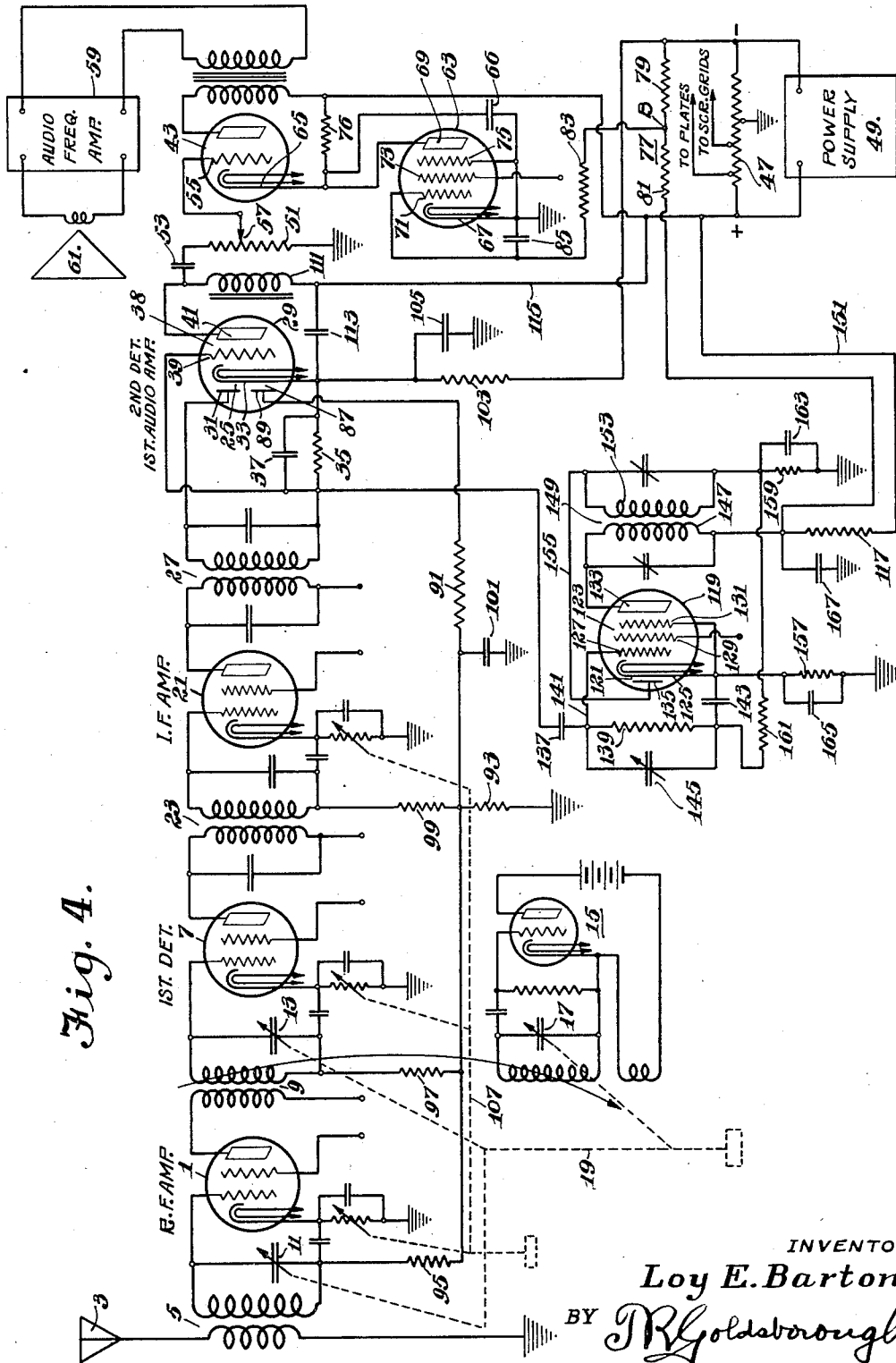


Fig. 4.

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2,028,859

RADIORECEIVER

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Application November 25, 1933, Serial No. 699,641

13 Claims. (Cl. 250—20)

My invention relates to radio receivers and more particularly to receivers which are provided with noise suppressor circuits for preventing "background" noise from being heard when tuning between stations.

Various noise suppressor circuits have been proposed since the development of automatic volume control circuits because an automatic volume control circuit makes the gain of a receiver the maximum when it is tuned off a station. Consequently, unless the receiver includes some type of noise suppressor, static and tube noises and other "background" noise will be amplified the maximum amount and be heard in the loud speaker when tuning from one station to another.

Heretofore, noise suppressor circuits have generally required the use of a special automatic volume control network including several additional amplifier tubes. Circuits of this type increase the cost of a receiver a substantial amount. Also, it has been found somewhat difficult and expensive to so design such noise suppressor circuits that the noise suppression is complete.

An object of my invention is to provide a radio receiver having a noise suppressor which does not involve the above-mentioned disadvantages.

A further object of my invention is to improve the apparent selectivity of a radio receiver, whereby the receiver must be accurately tuned to a signal before the signal can be heard.

In one embodiment of my invention I provide one of the audio frequency amplifier tubes with a self-biasing resistor in the form of the cathode-anode circuit of an electric discharge device such as a vacuum tube. The cathode-anode circuit or plate impedance of the vacuum tube is maintained at a high resistance value when no signals are being received, whereby the audio frequency amplifier is blocked. Upon the reception of an incoming signal, the plate impedance of the biasing tube is reduced in value sufficiently to unblock the audiofrequency amplifier so that the signal can be heard. Preferably, an amplifier having a "trigger" action is utilized for controlling the plate impedance of the self-biasing tube, in order that variations in said plate impedance shall be prevented during the reception of signals.

Other objects, features and advantages of my invention will appear from the following description taken in connection with the accompanying drawings in which

Fig. 1 is a circuit diagram of a radio receiver embodying one form of my invention;

Fig. 2 is a set of curves showing certain characteristics of the self-biasing vacuum tube utilized in the circuit shown in Fig. 1; and

Figs. 3 and 4 are circuit diagrams showing other embodiments of my invention.

Referring to Fig. 1, an embodiment of my invention is shown applied to a superheterodyne receiver which comprises a radio frequency amplifier 1 having an input circuit coupled to an antenna 3 through a radio frequency transformer 5. The output circuit of the amplifier 1 is coupled to the input circuit of a first detector 7 through a radio frequency transformer 9.

The secondary windings of the transformers 5 and 9 have tuning condensers 11 and 13, respectively, connected thereacross in the usual manner, for tuning the input circuits of the amplifier 1 and the first detector 7 to the desired incoming signal.

An oscillator 15 is coupled to the first detector 7 for the purpose of heterodyning an incoming signal to a lower intermediate frequency signal. The frequency of the oscillator output may be varied by means of a variable tuning condenser 17.

The tuning condensers 11, 13, and 17, are preferably units of a gang condenser, and may be varied simultaneously through a common tuning control indicated by the dotted line 19.

The intermediate frequency output of the first detector 7 is impressed upon the input circuit of an intermediate frequency amplifier 21 through an intermediate frequency transformer 23, the primary and secondary of which are tuned to make the transformer function as a band-pass filter having a pass range of sufficient width to pass the intermediate frequency carrier and at least one side band.

It will be understood, of course, that the tuned radio frequency circuits of the amplifier 1 and detector 7 are also tuned broadly enough to pass the carrier of the incoming radio signal and at least one of its side bands.

The output of the intermediate frequency amplifier 21 is fed to the second detector 25 through an intermediate frequency transformer 27 tuned in the same manner as the preceding transformer 23.

In the particular embodiment illustrated, the second detector 25 is a diode rectifier which is one unit of a double diode-triode vacuum tube 29, this rectifier having a plate 31 and a cathode 33.

One terminal of the secondary of the transformer 27 is connected to the detector plate 31, while the other terminal of the secondary is con-

connected to the cathode 33 through a resistor 35, the resistor 35 being shunted by means of an intermediate frequency bypass condenser 37.

The triode section 38 of the vacuum tube 29, which section functions as the first audio frequency amplifier, includes the cathode 33, a control grid 39 and an anode 41. The control grid 39 is connected to the plate end of the resistor 35, whereby any audio frequency signals appearing across resistor 35 are impressed across the input of the triode section 38 to cause amplified audio frequency signals to appear in the plate circuit thereof.

The amplified audiofrequency signal is impressed upon the input circuit of another audio frequency amplifier comprising an electric discharge device such as a vacuum tube 43. In one embodiment of the invention, the tube 43 is an RCA 56. The signal is impressed upon the input circuit of tube 43 through a coupling system which, in the embodiment shown, includes a coupling resistor 45 in the plate circuit of the triode section 38. The lower end of the coupling resistor 45 is connected to the positive terminal of a voltage divider 47 which is connected across any suitable D. C. power supply 49. Voltage divider 47 is connected to ground at a point intermediate the two terminals thereof.

The upper end of the coupling resistor 45 is coupled to a volume control resistor 51 through a coupling condenser 53, the lower end of the resistor 51 being connected to ground.

The control grid 55 of the amplifier 43 is connected to a point on the volume control resistor 51 through a variable volume-control tap 57.

The output of the amplifier 43 may be further amplified if desirable by means of any suitable audio frequency amplifier indicated at 59 and supplied to a loud speaker 61.

In accordance with my invention, the input circuit of the audiofrequency amplifier tube 43 includes an electric discharge device 63 which preferably is a vacuum tube of the pentode type such as an RCA 57. The cathode-anode circuit of the tube 63 is connected between the cathode 65 of the amplifier tube 43 and ground to function as a self-biasing resistor which may be given a very high resistance to block the amplifier tube 43 when tuning between stations. Connected in this way, the cathode-anode circuit of the tube 63 is common to the input and output circuits of amplifier 43 in the same manner as an ordinary self-biasing resistor. An audio frequency bypass condenser 66 is connected between the cathode 67 and the anode 69 of tube 63 in order to provide a low impedance connection from the grounded end of resistor 51 to the cathode 65.

The self-biasing tube 63 includes in addition to the cathode 67 and anode 69, a control grid 71, a screen grid 73, and a suppressor grid 75. In operation, the plate impedance of the tube 63 is changed from a very high resistance value to a comparatively low resistance value by changing the potential on the control grid 71 from a high negative value to nearly a zero value.

A resistor 76 of high resistance value is preferably connected between the plate 69 and the positive terminal of voltage divider 47 for supplying part of the plate and leakage current for the tube 63. The resistor 76 may be given a value of from one-fourth megohm to one megohm, the value not being critical since the plate impedance of amplifier tube 43 is so low compared with the impedance of resistor 76 that it, rather than resistor

76, determines the voltage drop between the voltage divider 47 and the plate 69 of tube 63.

One function of resistor 76 is to keep the plate voltage of the biasing tube 63 high during the period that the amplifier tube 43 is blocked. The general effect obtained by adding resistor 76 to the circuit is a more rapid and positive action of the noise suppressor.

The control circuit for the self-biasing tube 63 includes a potentiometer 77 which is connected at one end to the negative terminal of the voltage divider 47, and at the other end to the plate end of the coupling resistor 45. The potentiometer includes two resistors 79 and 81 each of which may have a resistance value of approximately 1 15 megohm.

The control grid 71 of biasing tube 63 is connected to a point on the potentiometer between the two resistors 79 and 81 through a filter resistor 83 which may have a resistance value of approximately one megohm. An audio frequency bypass condenser 85 is connected between the control grid 71 and the cathode 67 for preventing audio frequency signals from being impressed upon control grid 71 and thereby varying the plate impedance of the biasing tube during the reception of signals.

The point on the potentiometer 77 to which the control grid 71 is connected, which is identified as point B on the drawings, is preferably so chosen that it is highly negative with respect to ground when there is no incoming signal. For example, the point B may be at -20 volts with respect to ground, which is sufficient to block the biasing tube 63, thereby causing its plate impedance to be so high that the audio frequency amplifier 43 is blocked.

When there is no incoming signal, the high negative voltage is maintained on the control grid of the biasing tube 63 in the following manner: With no incoming signal, the control grid 39 of the first audiofrequency amplifier 38 is at substantially the same potential as the cathode since the current flow through resistor 35 is small. Therefore, the plate current flowing through the coupling resistor 45 has a fairly high value, and the upper end of resistor 45 is at a low positive potential. As previously stated, the point B is so chosen that under these conditions, it is highly negative with respect to ground.

When a signal is tuned in, the control grid 39 of amplifier 38 becomes more negative, and the plate current through the coupling resistor 45 is decreased in value, whereby the upper end of resistor 45 becomes more positive. This causes the point B to become sufficiently less negative to unblock the biasing tube 63. This results in the plate impedance of the biasing tube 63 being reduced in a value low enough to apply a normal biasing potential to the control grid 55 of the audio frequency amplifier 43, and the signal is transmitted to the loud speaker 61.

As will be explained in connection with Fig. 2, the self-biasing tube 63, when of the pentode or suppressor grid type, will have a constant plate impedance over a fairly wide variation in control grid voltage. Obviously, however, the voltage applied to the control grid 71 must be held within reasonable limits during the reception of a signal or the plate impedance of the tube 63 will vary and cause distortion of the signal.

In order to prevent too great variations in the control grid voltage and resulting signal distortion, I provide the receiver with an automatic

volume control circuit and with a sensitivity control device.

While various forms of automatic volume control may be utilized, the circuit illustrated in the drawings is simple and effective in operation. It includes one of the diode rectifiers 87 of the vacuum tube 29, this diode comprising the cathode 33 and a plate 89. The plate 89 is connected through a filter resistor 91 and a volume control resistor 93 to ground. Resistor 93 may have a resistance of the order of 500,000 ohms.

The junction point of the resistors 91 and 93 is connected to the control grids of the tubes 1, 7, and 21 through resistors 95, 97, and 99, respectively. A filter condenser 101 is connected between the grid end of the filter resistor 91 and ground.

The cathode 33 is connected to the negative end of the voltage divider 47 through an automatic volume control resistor 103. This resistor, which is bypassed by means of an audiofrequency bypass condenser 105, may have a resistance of the order of 40,000 ohms.

The operation of the automatic volume control circuit is as follows: Assuming that a strong signal is being received, there is then maximum flow of current through the second detector resistor 35, and the control grid 39 is at a rather high negative potential, whereby the plate current of triode section 38 is small and there is a small voltage drop in the volume control resistor 103. Therefore, the greater part of the voltage across the lower section of the voltage divider 47 is impressed upon the diode 87.

This will be seen by noting that the grounded point of the voltage divider 47 is connected to the plate 89 of the diode rectifier 87 through a connection which may be traced from ground and through the volume control resistor 93, this grounded point being positive with respect to the cathode 33. The voltage across this lower section of 47 the voltage divider is large compared with the voltage drop in the volume control resistor 103 under the conditions assumed, so that although the two voltages are in opposition, the voltage applied to rectifier 87 is only slightly less than the voltage across said lower section.

This results in a comparatively large flow of current through the automatic volume control resistor 93, with the result that the voltage drop in resistor 93 maintains the control grids of the tubes 1, 7, and 21 highly negative with respect to their cathodes, whereby their gain is held at a low value during the reception of the strong signal.

If the strength of the received signal becomes less, the control grid 39 becomes less negative, the plate current and the voltage drop in the resistor 103 increase, and a lower voltage is impressed across the rectifier 87. As a result, the current flow through the volume control resistor 93 decreases and the control grids of the tubes 1, 7, and 21, become less negative, whereby the gain of the receiver is increased to bring up the signal strength. The above described automatic volume control circuit is described and claimed in my copending application Serial No. 640,946, filed November 3, 1932, and assigned to the same assignee as this application.

In order to provide sensitivity control for the receiver the self-biasing resistors of tubes 1, 7, and 21 may be made variable and connected together through a common sensitivity control indicated by the dotted line 107. By adjusting the sensitivity control, the point at which the automatic volume control circuit will start to function

may be determined. Thus the sensitivity control may be so adjusted that only signals will be received which have a signal strength sufficient to reduce the bias on the control grid 71 of the self-biasing tube 63 to a certain predetermined value, such as a value of approximately -3 volts. In the specific case where the self-biasing tube 63 is of the type known as RCA 57, this will prevent the receiver from operating under conditions where the plate impedance of the biasing tube changes during the reception of a signal.

This feature will be more fully understood by referring to Fig. 2, which shows a family of plate curves for the RCA 57 tube. It will be seen that the plate curves for this tube, as well as for other tubes of the same general type, are concave downward. The most important fact to be noted from these curves is that the plate impedance of the RCA 57 tube is substantially constant for control grid voltages between zero and -3 volts when the plate voltage is very low. This fact is indicated by the dotted line 109 which shows how the plate curves all fall along a straight line at a low value of plate voltage for control grid voltages between zero and -3 volts. It will be seen that as the control grid becomes more negative than -3 volts, the curves no longer fall along the line 109, showing that the plate impedance of the tube changes with a change in the control grid voltage at the more negative grid bias.

If the receiver were permitted to operate with the control grid 71 of the biasing tube 63 at approximately -5 volts, for example, the plate impedance would vary and the operation of the receiver would not be satisfactory. It will be seen, therefore, that by properly adjusting the sensitivity control, the A. V. C. circuit will cause the noise suppressor to operate under conditions which will produce an undistorted signal.

It has been pointed out above how the self-biasing tube 63 is prevented from operating with its control grid too negative. It is prevented from operating with its control grid positive more than a slight amount above zero voltage by means of the filter resistor which limits the positive voltage on the control grid as soon as grid current begins to flow.

As an inspection of Fig. 2 will indicate, the RCA 57 tube 63 should be operated at a plate voltage greatly below normal and at a grid bias which is almost zero. In one embodiment of the invention where the tube 63 is an RCA 57 and the tube 43 an RCA 56, the voltage on the plate of tube 63 is 13 volts, the screen grid voltage of tube 63 is about 90 volts, and the plate current in the two tubes is about 4 milliamperes. The grid bias of tube 43 is normally 13 volts while its cut-off bias is approximately 20 volts, this is assuming a normal plate voltage of 250 volts and a drop in plate voltage to about 170 volts as the tube is biased to cut-off.

It should be noted that tube 43 is biased to cut-off very rapidly since its plate voltage is reduced in value as the biasing voltage is increased. The above-mentioned plate voltage reduction to 170 volts is caused by an 80 volt drop across the tube 63 produced when it is biased substantially to cut-off during the period that no signal is being received. It will be seen that the 80 volt drop is much greater than the bias voltage required for biasing tube 43 to cut-off, whereby the noise suppression is complete.

If desired, the receiver shown in Fig. 1 may be operated without noise suppression by closing the

switch 104, thus connecting the control grid 71 to ground through resistor 83.

A modified form of my invention is shown in Fig. 3, like parts in Figs. 1 and 3 being indicated by the same reference numerals. In order to simplify the drawings, no automatic volume control circuit has been illustrated. In this modification, the cathode 33 of the first audio frequency amplifier tube 29 is connected to the negative terminal of the voltage divider 47, whereby the potentiometer 77 of Fig. 1 may be omitted. Instead of being connected to a point on a potentiometer, the control grid 71 of the biasing tube 63 is connected to the upper end of the coupling resistor 45. The voltage divider 47 and the coupling resistor 45 are so adjusted that when there is no incoming signal, the control grid 71 is sufficiently negative with respect to its cathode 57 to block the tube 63, as described in connection with Fig. 1. It will be noted that this adjustment can be made readily by grounding the voltage divider 47 at a point such that the voltage drop in the coupling resistor 45 will be greater than the voltage across the upper section of the voltage divider. By employing this circuit, the noise suppressor may be made to respond to an incoming signal somewhat more rapidly than when employing the circuit shown in Fig. 1 because the absence of the potentiometer 77 results in the grid circuit of the biasing tube 63 having a shorter time constant.

In the embodiment of my invention shown in Fig. 4, there is an additional control circuit for the noise suppressor, this control circuit being provided both for the purpose of increasing the effective or apparent selectivity of the receiver and for preventing operation of the self-biasing tube 63 under conditions that might produce signal distortion. In Figs. 1 and 4, like parts are indicated by the same reference numerals.

Referring to Fig. 4, the coupling circuit between the first audio frequency amplifier 38 and the second audio frequency amplifier 43 preferably includes a choke coil 111 in the plate circuit of the amplifier 38. An audio frequency bypass condenser 113 is connected between the lower end of the choke coil 111 and the cathode 33. The lower end of the choke coil 111 is connected to the positive terminal of the voltage divider 47 through a conductor 115.

As in the circuit shown in Fig. 1, the control grid 71 of the biasing tube 63 is connected to a potentiometer 77, but in this case the potentiometer 77 is connected between the negative terminal of the voltage divider 47 and the upper end of a plate resistor 117 which is included in the plate circuit of a control tube 119 in the above-mentioned control circuit.

The control tube 119 is preferably a diode-pentode vacuum tube having a diode section 121 and a pentode section 123. The pentode section includes a cathode 125, a control grid 127, a screen grid 129, a suppressor grid 131, and an anode 133. The diode section includes the cathode 125 and a plate 135.

The input circuit of the pentode section 123 is coupled to the second detector resistor 35 in any suitable manner for impressing the low intermediate frequency voltage drop thereof across the pentode amplifier input electrodes. In the drawings, this coupling device is shown as a small coupling condenser 137, having a comparatively low impedance to signals at the intermediate frequency, but having an impedance to audio frequency signals sufficient to prevent any appreci-

able audio frequency voltage from being impressed upon the input circuit of pentode section 123.

A resistor 139 is provided which is connected at one end to the control grid 127 through a conductor 141, and connected at the other end to the cathode 125 through an audio frequency bypass condenser 143. The resistor 139 is shunted by a variable condenser 145 which may be adjusted for the purpose of controlling the input voltage to the pentode amplifier 123.

The plate circuit of the pentode section 123 includes the primary winding 147 of a transformer 149 and the resistor 117, the primary winding and the resistor being connected in series, and the lower end of the resistor being connected to a positive point on the voltage divider 47 through a conductor 151.

The secondary winding 153 of the transformer 149 is loosely coupled to the primary winding 147, and both the primary and the secondary are tuned so that the transformer is tuned very sharply to the intermediate frequency. Thus, the tuning of the noise suppressor circuit is much sharper than the tuning of the signal channel.

The amplified intermediate frequency output of the pentode section 123 is transferred through the sharply tuned transformer 149 and impressed upon the elements 125 and 135 of the diode rectifier through a conductor 155 (which connects the diode plate 135 to one terminal of the secondary winding 153), and through a connection from the cathode 125 to the other terminal of the secondary 153, which connection may be traced from the cathode 125 through a self-biasing resistor 157 to ground, through ground to the lower terminal of a resistor 159, and through the resistor 159 to the said other terminal of secondary 153. Resistor 159 may be given a value of the order of $\frac{1}{2}$ megohm.

The function of the diode rectifier 121 is to increase the negative bias on the control grid 127 of the pentode section upon reception of a radio signal. Since a flow of current through the rectifier 121 causes the upper end of the resistor 159 to become negative, the control grid 127 also becomes more negative because of its connection to the negative end of the resistor 159 through the resistor 139 and a high impedance resistor 161. Resistor 161 may have a resistance value of the order of $\frac{1}{2}$ megohm.

Obviously an audio frequency signal will appear in the circuit of rectifier 121 which should not be impressed upon the control grid 127 of the pentode section. This is prevented by the audio frequency bypass condenser 143. The resistor 159, the self-biasing resistor 157 and the plate resistor 117 are shunted by the usual intermediate frequency bypass condensers 163, 165 and 167, respectively.

It will be apparent from the foregoing description that as soon as an intermediate frequency signal is impressed upon the input circuit of the pentode amplifier 123, the control grid 127 of that amplifier will become more negative because of the current flow through the circuit of the rectifier 121.

It may be noted that the change in bias on the control grid 127 depends, to a certain extent, upon the voltage drop produced in the self biasing resistor 157, since this voltage drop is in series with the voltage drop along the resistor 159 of the diode circuit. That these voltage drops are in series will be made evident by tracing the direct current path of the pentode section input

circuit. It may be traced from the control grid 127 through the coupling resistor 139, the high impedance resistor 161, through the diode circuit resistor 159 to ground, through ground to the self-biasing resistor 157, and through the self-biasing resistor 157 to cathode 125.

When there is no incoming signal, the plate current of the pentode amplifier 123 is large, since the only negative bias on the control grid 127 is that due to the self-biasing resistor 157, and this negative bias is comparatively small. Consequently there is a large voltage drop in the plate resistor 117, whereby the upper end of resistor 117 is at a fairly high negative potential with respect to the positive end of the voltage divider 47. Also, the gain of the amplifier 123 is low because of the low voltage of its anode 133.

As soon as the receiver is tuned to an incoming carrier wave, the amplifier 123 supplies signal energy to the diode 121, the voltage drop in the diode circuit resistor 159 increases the negative bias on the control grid 127, whereby the plate current of amplifier 123 decreases and the upper end of the plate resistor 117 becomes less negative and the voltage applied to anode 133 is increased. This increases the gain of amplifier 123, and causes a further decrease in plate current through resistor 117, this action continuing until the plate voltage builds up to a maximum value. At this point the gain may have decreased because of relatively high bias. It is the potential at the upper end of the plate resistor 117 which is utilized for actuating the noise suppressor.

It should be noted that although the decrease in plate current tends to cause a reduction in the biasing voltage in the self-biasing resistor 157, the increased negative bias provided by the current flow through the diode circuit resistor 159 is much greater than any decrease in bias due to reduction in plate current.

The above described action of the diode-pentode circuit, whereby the upper end of the plate resistor 117 becomes less negative in response to reception of a radio signal, is a "trigger" action which is obtained by giving plate resistor 117 a proper resistance value. This value is not critical and may be between 50,000 and 100,000 ohms. This "trigger" action depends upon the fact that the increase in gain caused by the increase in the plate voltage is greater than the decrease in gain caused by the increase in negative bias on the grid 127 up to a certain bias after which the gain decreases. In the particular circuit described above, an RCA 2B7 tube has been employed for the tube 119 with satisfactory results.

It may be noted that the gain of the usual three-element vacuum tube remains substantially constant over a wide variation in plate voltage so that it is not suitable for providing a "trigger" action in my control circuit. It should be understood, however, that it is not essential that the amplifier 123 be adjusted to operate as a "trigger" amplifier, although, for reasons explained below, such an adjustment is highly desirable.

The "trigger" action adjustment is preferred as the control circuit then never permits the control grid 71 of the biasing tube 63 to remain at a voltage such that the tube operates with the plate impedance changing with comparatively small variations in grid voltage. As soon as a signal is received, the "trigger" action of the control circuit causes the bias on the control grid of the biasing tube to change abruptly from its high negative value of -20 volts, for example, to a value which is approximately zero, for example, in the region

where the impedance of the plate circuit is constant during minor variations in control grid voltage.

The use of a resistor in the plate circuit of a pentode for providing a "trigger" amplifier is described and claimed in my co-pending application Serial No. 704,510, filed December 29, 1933 and assigned to the same assignee as this application.

It will be seen that the apparent selectivity of the receiver illustrated in Fig. 4 is determined largely by the sharpness of the tuning of the transformer 149. Unless the receiver is tuned exactly to the carrier frequency of a signal, the amplifier tube 43 will remain blocked, and the signal will not be heard.

It should be understood that while I have referred to specific types of tubes and specific impedance and voltage values, the invention is not limited to the use of such tubes and values. They have been referred to only for the purpose of making my invention more readily understood.

Various modifications in addition to the ones described may be made in my invention without departing from the spirit and scope thereof and I desire, therefore, that only such limitations shall be placed thereon as are necessitated by the prior art and set forth in the appended claims.

I claim as my invention:

1. In a radio receiver having a signal channel, an electric discharge tube in said signal channel, said tube having a cathode, an anode and a control grid, and a control tube having a cathode-anode space discharge path, said control tube being connected with said space discharge path common to the anode and control grid circuits of said electric discharge tube whereby it functions as a self-biasing resistor for said control grid.

2. In a radio receiver, an audiofrequency amplifier including an electric discharge device having a cathode, an anode, and a control electrode, an input circuit including said cathode and said control electrode, an output circuit including said cathode and said anode, and a second electric discharge device having a cathode-anode space discharge path common to said input circuit and said output circuit whereby it functions as a self-biasing resistor for said control electrode.

3. A radio receiver according to claim 2 characterized in that the receiver includes means for controlling the impedance of said space discharge path in response to an incoming radio signal.

4. In a radio receiver, a plurality of electric discharge devices connected in cascade, at least one of said devices having a cathode, an anode, and a control electrode, said one device having an input circuit including said cathode and said control electrode, said one device also having an output circuit including said cathode and said anode, and a second electric discharge device having a cathode-anode space discharge path common to said input circuit and said output circuit, and means for controlling the impedance of said space path in response to an incoming signal.

5. A radio receiver according to claim 4 characterized in that the second discharge device has a control electrode which is maintained at a negative potential sufficient to bias said second device to cut-off when no incoming signal is being received.

6. A radio receiver according to claim 4 characterized in that when no incoming signal is being received the impedance of said space path is sufficient to bias said first discharge device to cut-off.

7. In combination, an electric discharge device having an input circuit and an output circuit, and a pentode having a cathode-anode space discharge path which is common to said input and output circuits whereby it functions as a self-biasing resistor for said device.

8. Apparatus according to claim 7 characterized in that means is provided for controlling the potential on the control grid of the pentode.

9. In combination, an electric discharge device having an input circuit and an output circuit, and a vacuum tube of the suppressor grid type having a cathode-anode space discharge path which is common to said input and output circuits whereby it functions as a self-biasing resistor for said device.

10. In a radio receiver, a plurality of amplifiers connected in cascade, one of said amplifiers including an electric discharge device having an input circuit and an output circuit, a space discharge device having a space discharge path and a control electrode, said space discharge path being common to said input and output circuits, said space discharge device having the characteristic that for a certain range of potentials applied to said control electrode the impedance of said space discharge path remains at a substantially constant and comparatively low value, means for normally maintaining said control electrode at a potential which causes the im-

pedance of said space discharge path to be high, and means for changing the potential of said control electrode to a value within said certain range in response to an incoming signal.

11. A receiver according to claim 10 characterized in that said last means includes a trigger amplifier whereby said control grid potential is changed suddenly and positively to a value within said certain range in response to an incoming signal.

12. In combination, an electric discharge device having an output circuit and an input circuit including a control electrode, and an electric discharge device having a cathode-anode space discharge path common to said input and output circuits whereby a voltage drop across said space discharge path is applied to said control electrode to supply a biasing potential thereto, said second device having the characteristic that its plate current plotted against plate volts is represented by a curve which is concave downward.

13. Apparatus according to claim 12 characterized in that said second device has a control electrode and is operated at a plate voltage and at control electrode voltages having values so low that the impedance of said space path remains substantially constant during variations of said control electrode voltages.

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