Feb. 9, 1937. J. J. BRAND 2,070,354

RADIO RECEIVING CIRCUIT

Filed Aug. 3, 1934 6 Sheets-Sheet 1

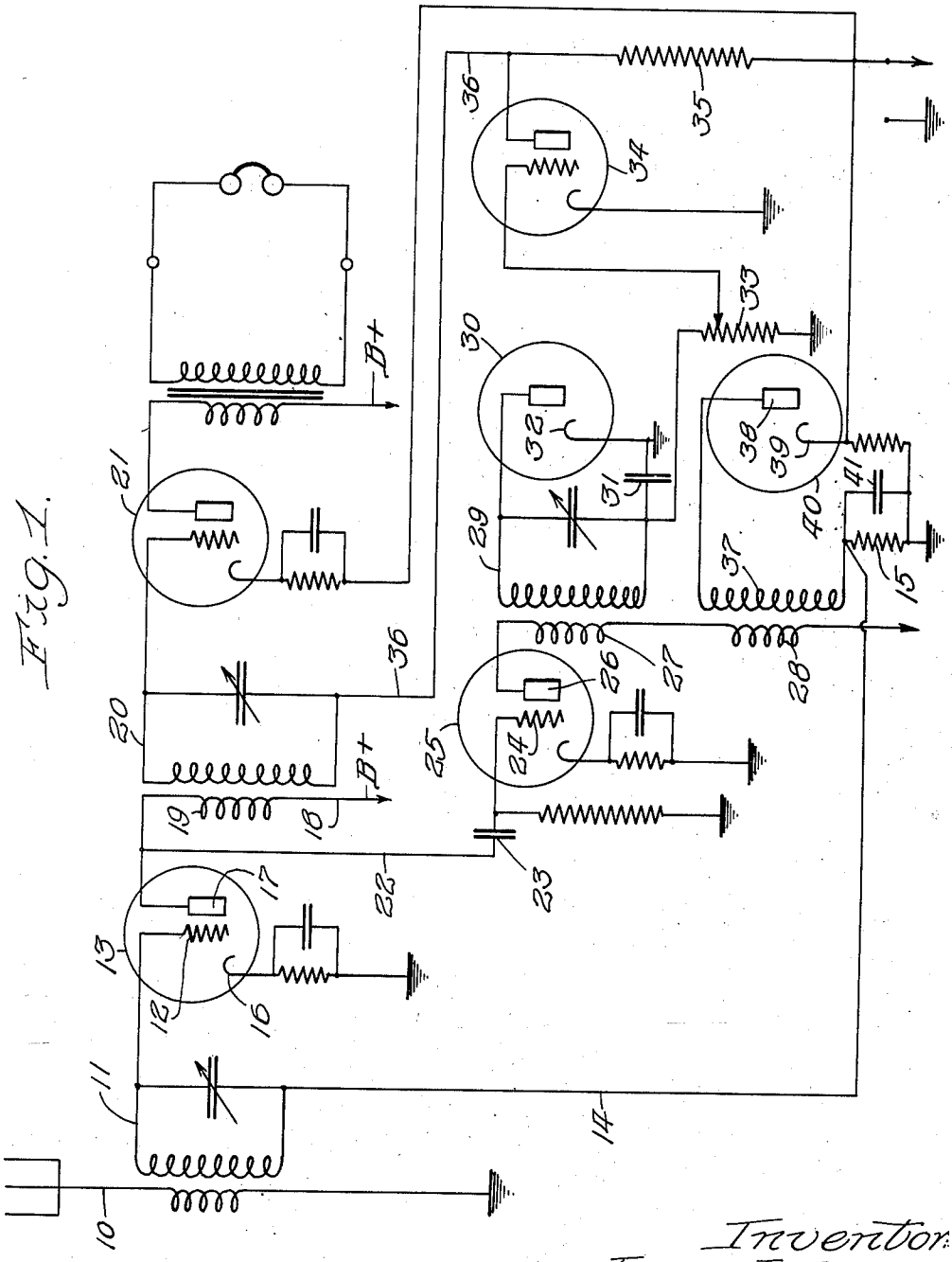


Fig. 1.

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Feb. 9, 1937. J. J. BRAND 2,070,354

RADIO RECEIVING CIRCUIT

Filed Aug. 3, 1934 6 Sheets-Sheet 2

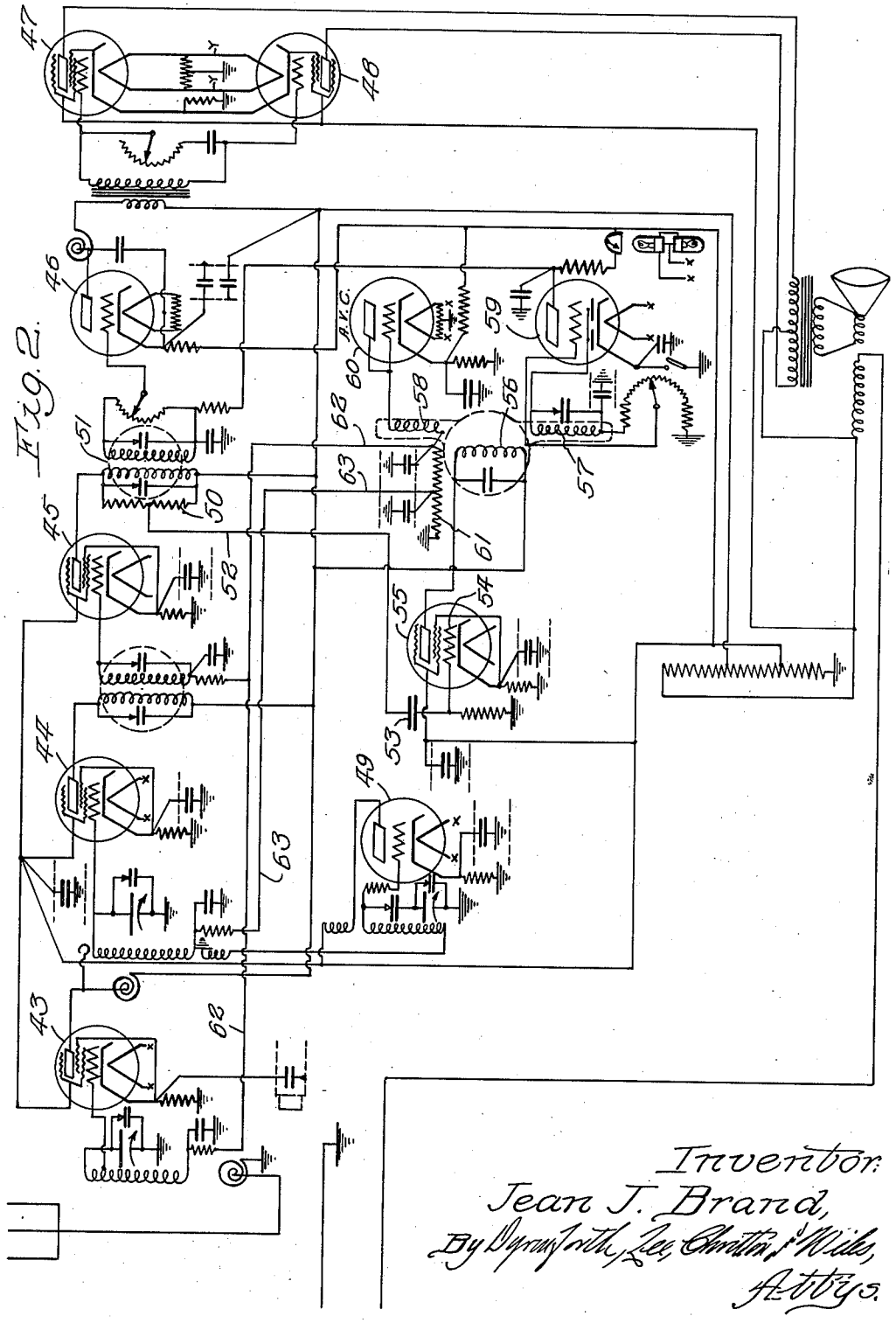


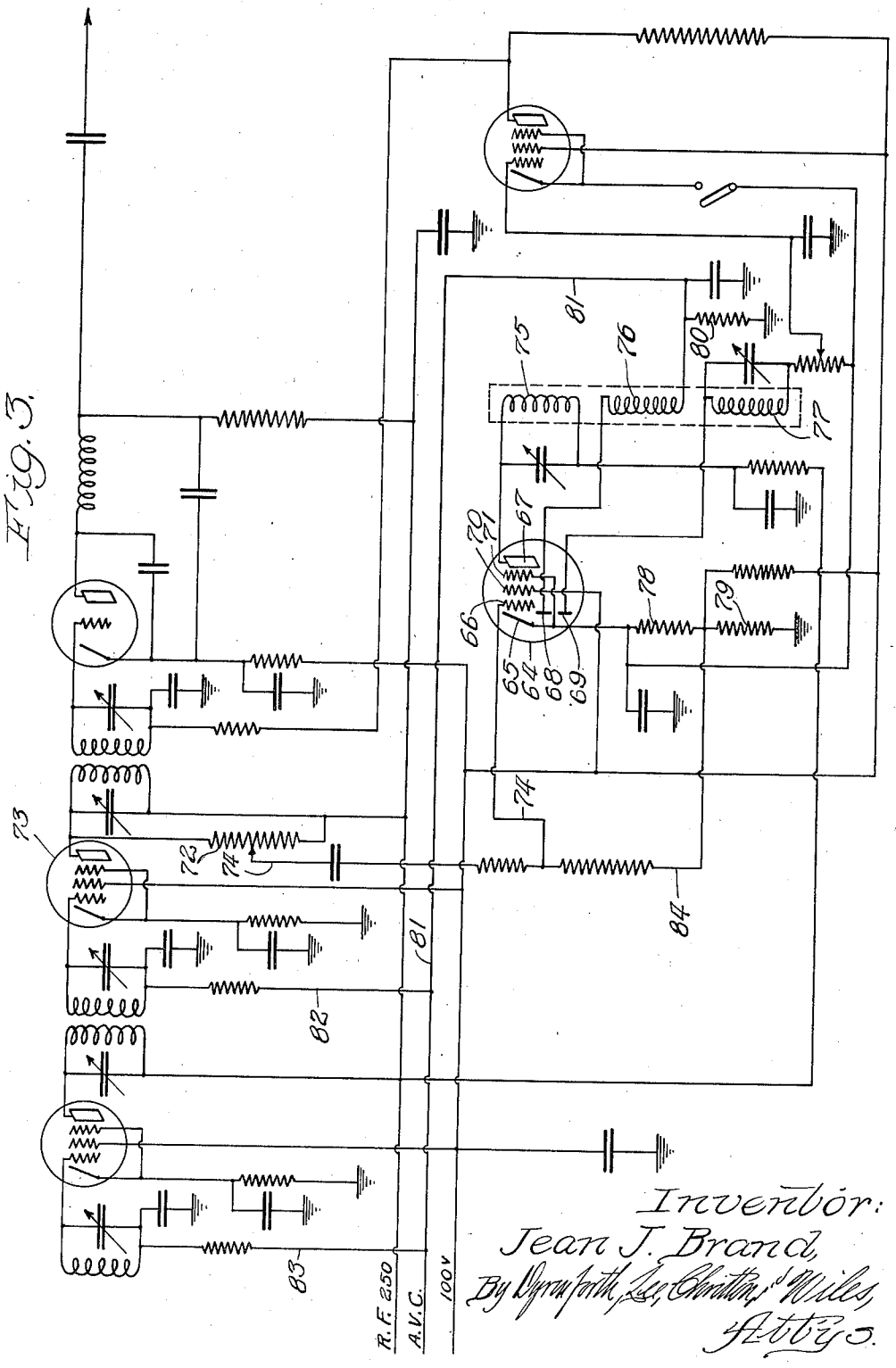
Fig. 2.

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Feb. 9, 1937. J. J. BRAND 2,070,354

RADIO RECEIVING CIRCUIT

Filed Aug. 3, 1934 6 Sheets-Sheet 3



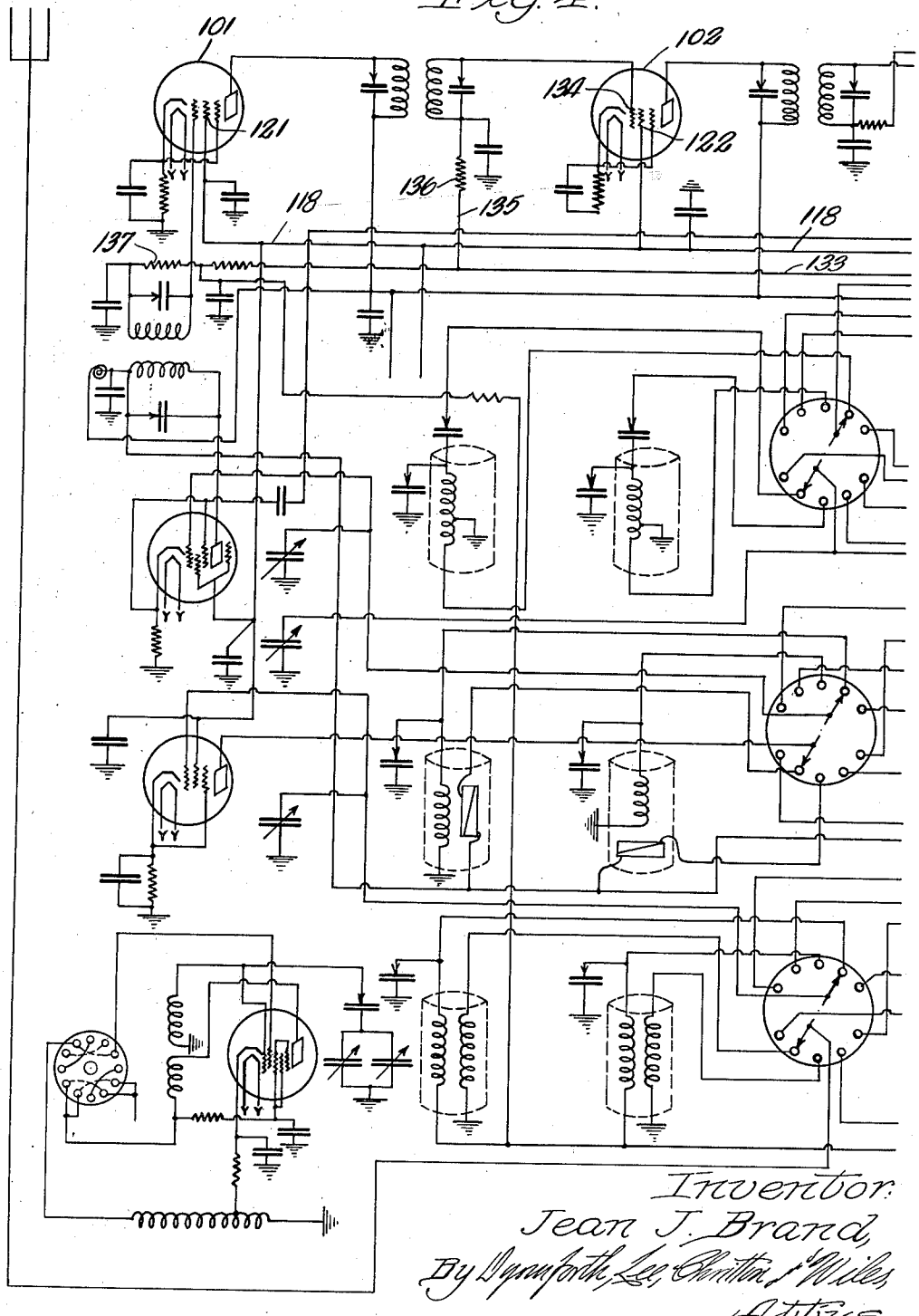
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Feb. 9, 1937. J. J. BRAND 2,070,354

RADIO RECEIVING CIRCUIT

Filed Aug. 3, 1934 6 Sheets-Sheet 4

Fig. 4.



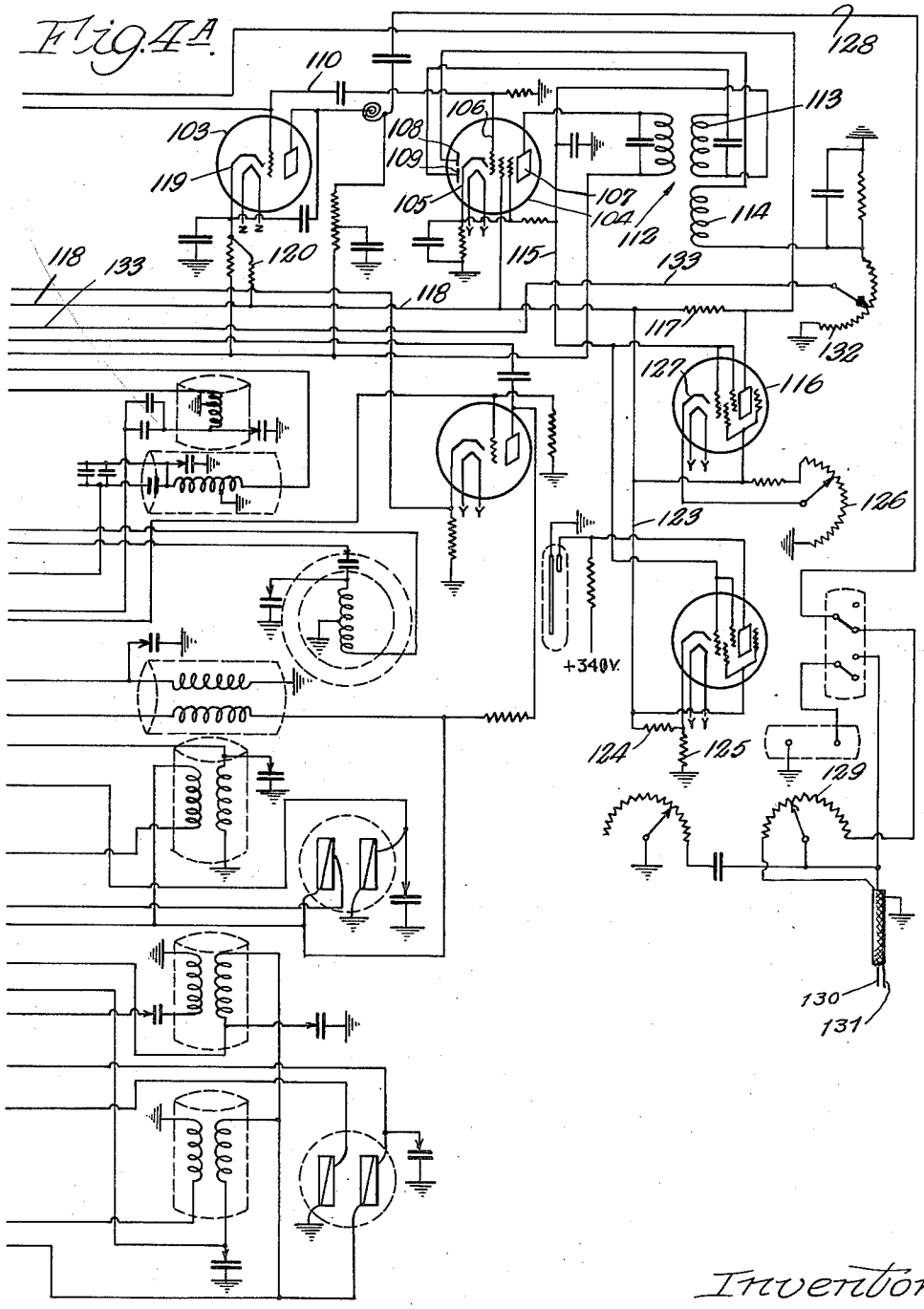
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RADIO RECEIVING CIRCUIT

Filed Aug. 3, 1934 6 Sheets-Sheet 5

Fig. 4A.



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Feb. 9, 1937. J. J. BRAND 2,070,354

RADIO RECEIVING CIRCUIT

Filed Aug. 3, 1934 6 Sheets-Sheet 6

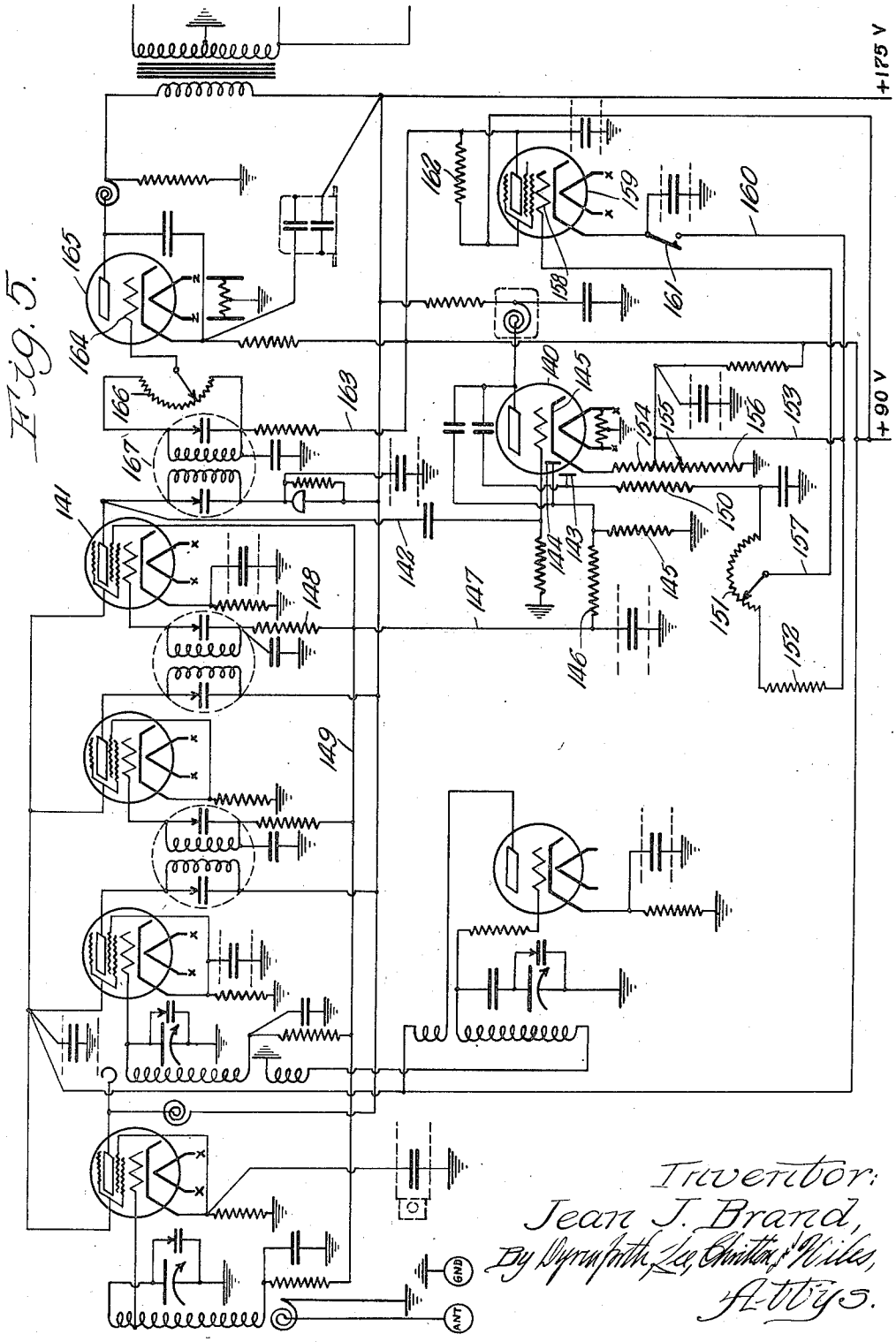


Fig. 5.

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Patented Feb. 9, 1937 2,070,354

UNITED STATES PATENT OFFICE

2,070,354

RADIO RECEIVING CIRCUIT

Jean J. Brand, Chicago, Ill., assignor of one-half to George A. Chritton and one-half to Thomas J. Sullivan, both of Chicago, Ill.

Application August 3, 1934, Serial No. 738,344

8 Claims. (Cl. 250—20)

This invention relates to automatic volume controls, and more particularly to a circuit wherein the signal is amplified before being rectified for automatic volume control purposes. This application is a continuation in part of my co-pending application for a Radio receiving circuit, Serial No. 667,734, filed April 24, 1933.

One feature of this invention is that it amplifies a signal before impressing it upon the diode or rectifier tube used to develop the automatic volume control voltage; another feature of this invention is that it maintains a substantially level output volume throughout a wide range of signal input; still another feature of this invention is that it interposes a delay action, whereby the automatic volume control does not come into operation until the signal voltage has risen above a desired predetermined level; yet another feature of this invention is that it prevents excessive background noises when tuning between stations; and other features and advantages of this invention will be apparent from the following specification and the drawings, in which—

Fig. 1 is a diagrammatic view of this invention, in combination with a simple receiving circuit; Fig. 2 is a diagrammatic view of a superheterodyne circuit embodying this invention; Fig. 3 illustrates a circuit wherein a multi-electrode tube performs the combined function of amplifier and rectifier; Figs. 4 and 4a are schematic diagrams of a present-day receiver embodying this invention; and Fig. 5 is a schematic diagram of a receiver having delay action in the system.

Automatic volume control is a very desirable feature in a modern radio receiving circuit since it enables a receiver to be tuned from station to station without re-setting of the manual volume control at each station, in order to maintain the output at the level desired by the listener. Automatic volume control also maintains the set output constant despite fluctuations in a signal input caused by fading, when the set is tuned to a distant station. It has been found, however, that while a certain amount of automatic volume control can be achieved by diverting part of the signal to a rectifier, then passing the output of this rectifier through a resistance which impresses the bias developed across it upon one or more of the tubes in the receiving circuit, this system is not entirely satisfactory. The diverted portion of the signal must of necessity be small, in order not to seriously affect the overall gain of the receiver, and therefore very little current is developed across the biasing resistance. The output, moreover, cannot be held as level as is desirable. This invention, by inserting an amplifying tube ahead of the diode, maintains a much more perfect level of output with a much smaller diversion of current, since the diverted signal may be amplified several hundred times before it is impressed on the diode. This circuit, moreover, also permits of much greater flexibility, since the amplification factor of the tube preceding the diode may be chosen to give the best results in any particular receiver. Since the automatic volume control action is exerted prior to the demodulator or detector tube, the average input voltage on the grid circuit of that tube is maintained substantially constant, thus ensuring not only a substantially constant output, but also an output with the minimum of undesirable distortion. The diversion of signal is likewise greatly reduced and this also may be made a controllable variable. Where desired, as in Fig. 3, the amplifier and rectifier may be combined in a single tube, and delay action may be introduced with reference to the rectifying elements.

Fig. 1 illustrates a simple receiving circuit comprising a signal collecting system 10, having a tuned circuit 11 coupled to it. The voltage developed across this tuned circuit 11 is impressed on the grid 12 of a radio frequency amplifying tube 13. The grid return circuit is completed through the lead 14, and the biasing resistance 15 to ground, thence back to the cathode 16. It is this resistance 15 which performs the control function necessary in automatic volume control. The plate 17 of the tube 13 is maintained at a positive voltage by a lead 18 from a source of direct current. The main portion of the signal output in the plate circuit passes through the primary 19, and is transferred to the tuned circuit 20, which develops its voltage across the grid and cathode of the detector tube 21. Part of the signal output from the tube 13 is, however, diverted through the lead 22, and the blocking condenser 23, to the grid 24 of the amplifying tube 25. Here the signal is multiplied considerably, depending upon the amplification factor of the tube, and is then passed from the plate 26 through the two primaries 27 and 28. The primary 27 is coupled to the tuned input circuit 29 of the diode 30. A blocking condenser 31 is inserted between the tuned circuit 29 and the cathode 32, and therefore the rectified current in this tube must pass down through the resistance 33 to ground, and thence back to the cathode 32. The voltage developed across this resistance 33 is then passed through a squelch tube 34 in order to invert it,

and the voltage developed in the output of this tube across the resistance 35 is impressed upon the grid circuit of the detector 21 through the lead 36, to perform the automatic cutoff or squelch action which is desirable in a sensitive receiver having automatic volume control.

When the receiver is being tuned from one station to another there is a frequency band between carriers where no signal is impressed on the radio frequency amplifying tube 13, and therefore the automatic volume control makes available the full sensitivity of the receiver, with objectionable amplification of static and tube noises. Under such no-signal conditions the current through the squelch tube 34 is heavy, not being blocked by the grid, and the voltage developed across the resistor 35 is so large that the bias impressed between the grid and cathode of the detector tube 21 biases it below cutoff. Thus substantially no energy passes the tube 21 to cause sound in the earphones or loudspeaker until the receiver is tuned to a carrier, whereupon the received signal renders the squelch action of tube 34 inoperative and permits the receiver to operate with an overall amplification factor determined by the automatic volume control system.

The primary 28 is coupled to a secondary 37 which develops its voltage across the plate 38 and cathode 39 of the diode tube 40, through the resistor 15. A shunt to ground for the radio frequency current is provided through the condenser 41. It is this tube 40 which perfoms the automatic volume control action, since its rectified current flow passes through the resistance 15 and develops a voltage drop across it which is impressed upon the grid circuit of the radio circuit amplifier 13. Since the current flow in this circuit is from plate to cathode, it necessarily follows that the end of the resistance 15 to which the lead 14 is attached is maintained at a negative bias with respect to its other end, which is grounded. This negative bias is impressed on the grid 12 through the lead 14, and maintains it negative with respect to the cathode 16, which is also grounded.

Assuming the circuit to be operating at a desired output volume level, a change in signal input will operate as follows: Should the signal input double, the output would also double if no control action were present. The portion of the signal diverted through the lead 22, however, will now be double its previous value and thus the output of the tube 25 will also be doubled. This will result in a much larger transfer of energy to the automatic volume control tube 40 with a consequent double flow of current through the resistor 15. Following Ohm's law, if the current through the resistor 15 is doubled, the negative bias applied to the grid 12 of the tube 13 will likewise be doubled. This will result in cutting the amplification factor of the tube 13 in half and therefore the output of the receiver will not vary. This example assumes the amplifying tubes to be operating on a straight line portion of their amplification factor curves. In practice, however, the tubes quite frequently operate on portions of their characteristic curve having varying slopes, so that a more complex relationship exists, although the principle remains the same.

Fig. 2 shows this invention applied to a more sensitive superheterodyne circuit. In this circuit we have a radio frequency amplifier 43, a first detector 44, an intermediate frequency amplifier 45, a second detector 46, and a pair of push-pull tubes 47 and 48. The tube 49 is the oscillator furnishing the heterodyning wave. A potentiometer 50 is shunted across the primary 51 in the output circuit of the tube 55 and a lead 52 takes off a portion of the voltage developed across this potentiometer and applies it through the blocking condenser 53 on the control grid 54 of the tube 55. The output of this tube 55 passes through a primary 56, whereby an energy transfer is effected to the secondaries 57 and 58. The secondary 57 feeds the squelch tube 59, whereby interstation background noise is limited. The secondary 58 is in circuit with the elements of a rectifying tube 60, the current of which passes through a resistance 61 to develop the necessary control bias. A lead 62 takes off the entire voltage developed across the resistance 61 to apply it to the grid of the radio frequency amplifier. The lead 63 takes off a portion of the voltage developed across this resistance 61 and applies it to the grid of the first detector 44. It is thus seen that bias voltage may be furnished to more than one tube for control purposes, and also that the voltage furnished to each tube is not necessarily the same.

Fig. 3 illustrates a circuit wherein the functions of the amplifier, the automatic volume control tube and the squelch tube, are all combined in a single multi-element tube, such as the 6B7. This multi-element tube 64 has a cathode 65, a control grid 66, a plate 67, a pair of independent rectifying elements 68 and 69, and two shield grids 70 and 71 introduced for the purpose of stability of action. In this circuit a portion of the signal voltage is diverted from a potentiometer 72 connected in the output circuit of a tube 73, which may be an intermediate frequency amplifier for example, by the lead 74 which passes it to the control grid 66. This grid 66 controls the passage of current from the cathode 65 to the plate 67, and thus the signal voltage is amplified. The plate output circuit passes through a primary 75, from which energy is transferred to the secondaries 76 and 77. The secondary 76 is in circuit with the rectifier element 68, and voltage developed in said secondary causes a unidirectional current flow from said element 68 to the cathode 65 down through a split resistance 78 and 79 to ground, thence back through the resistance 80 and the secondary 76 to complete the circuit. The voltage developed across the resistance 80 is impressed upon the grids of the desired number of tubes by the lead 81 and the branch leads 82 and 83, for example. The control grid 66 of the tube 64 receives the bias developed across the resistance 78, since the grid return circuit is made through the lead 84 to the bottom of the last-named resistance. The additional resistance 79 is inserted between this point and ground in order to maintain the two rectifier elements 68 and 69 at a more negative potential with respect to the cathode 65 than is the grid 66. Due to this additional bias of the rectifier elements the tube 64 will function as an amplifier before the rectifier elements come into play, which will not take place until the amplified signal voltage is sufficient to overcome the negative bias imposed by the resistances 78 and 79. The point at which the rectifier elements will commence to operate will be determined by proper choice of the resistance 79. In a conventional modern receiver this value is so chosen that no rectifying will occur until the signal input has risen above 10 or 20 microvolts, thus permitting the full sensitivity of the receiver to be

utilized to amplify any signal below that level. This delay action enables much greater sensitivity to be realized than is the case where the automatic volume control is operative down to the extreme limits of sensitivity of the receiver. Moreover, once the rectifying elements do come into play the control action almost immediately becomes straight line, rather than the long slope found ahead of the level portion of the output curve in receivers having no delay action. The potentiometer 72 is variable, and thus permits any desirable portion of the signal voltage to be diverted to the tube 64 through the lead 74.

Figs. 4 and 4a illustrate an embodiment of this invention in a commercial multi-tube receiver. Tubes 101 and 102 are intermediate frequency amplifiers feeding the second detector or demodulator 103. Tube 104 performs the functions of an amplifier and a rectifier, containing the cathode 105, the grid 106, the plate 107, and in addition, the two rectifying elements 108 and 109. The output of the set is taken from the second detector 103 through the lead 128 and the variable resistor 129 to the output leads 130 and 131. It will be noted that a part of the current fed to the grid of the tube 103 is diverted through the lead 110 to the grid 106 of the tube 104.

This tube is in a circuit which is distinct from the regular output circuit of the set, and amplifies the diverted voltage, then passes it through the primary 111 of the transformer 112. This transformer has two secondaries, 113 and 114, which secondaries feed into the rectifying elements 109 and 108 respectively. The rectified voltage developed by the secondary 113 is fed through the lead 115 to the grid of the suppressor tube 116. The output of this tube 116 develops a voltage drop across the resistor 117, which voltage drop is applied to the cathode 119 of the second detector 103 through the lead 118 and the resistor 120. The lead 118 also continues to the intermediate frequency amplifiers, and a voltage is applied by it to the grids 121 and 122 of the tubes 101 and 102. The plate circuit for the tube 116 is completed through the lead 123 and the resistors 124 and 125 to ground, and thence back through the manually variable resistor 126 to the cathode 127.

The secondary 114 of the transformer 112 cooperates with the rectifying element 108 to develop a direct current through the manually variable resistor 132. Part of the direct current voltage drop across this variable resistor 132 is taken off by the adjustable lead 133 to secure automatic volume control action. The lead 133 develops a D. C. bias on the grid 134 of the tube 102 through the lead 135 and the resistor 136. Similarly, a bias is placed on one of the grids of the tube 101 through the resistor 137.

In the commercial embodiment of this invention illustrated in Fig. 5, the tube 140 is a duodiode-triode, serving to amplify through its triode elements a part of the signal voltage diverted from the intermediate frequency amplifier tube 141 through the lead 142, and then to develop direct current potential for use in connection with automatic volume control and noise suppression by means of its diode elements 143 and 144, which elements cooperate with the cathode 145 to rectify the amplified diverted signal voltage. The automatic volume control voltage is developed by the rectifier element 144 across the resistance 145, and then applied through the resistance 146, the lead 147, and the resistance 148 to the grid of the intermediate frequency amplifier 141, for example. It will be noted that the lead 147 is connected to the lead 149, and that the automatic volume control voltage is thus applied to the other intermediate frequency amplifiers, and to the radio frequency amplifiers, as here, if that is desired.

The rectifier element 143 completes its cathode circuit through the resistance 150, the variable resistance 151, and resistance 152, the lead 153 and a part 154 of the resistance 155 to the cathode 145. It will be noted that the resistance 155 is divided into two parts, 154 and 156. It is this rectifier return to an intermediate point of the resistance 155 which results in delayed action in the A. V. C. circuit. Any desired part of the voltage developed across the manually variable resistor 151 is applied through the lead 157 to the grid 158 of the noise suppressor tube 159, the grid return circuit of which is completed through the resistor 152, the lead 160, and the switch 161. The plate output of the suppressor tube 159 develops a D. C. voltage across the resistor 162, which voltage is applied through the lead 163 to the grid 164 of the second detector 165. The grid 164 is coupled to the intermediate frequency amplifier 141 through the potentiometer 166 and the transformer 167.

While I have shown and described certain embodiments of my invention, it is to be understood that it is capable of many modifications. Changes, therefore, in the construction and arrangement may be made without departing from the spirit and scope of the invention as disclosed in the appended claims, in which it is my intention to claim all novelty inherent in my invention as broadly as possible in view of the prior art.

What I claim as new and desire to secure by Letters Patent is:

1. A circuit of the character described, including; a signal source; an amplifying tube having a cathode and a grid; an output circuit for said amplifying tube; a second circuit whereby a portion of said output may be diverted; a multi-element tube having therein a cathode, a grid, a plate, and a rectifying element; means whereby said second circuit is coupled to said grid; means whereby the output in the plate circuit of said multi-element tube is rectified by said rectifying element; a resistance in the output circuit of said rectifying element; and means whereby the voltage developed across said resistance is impressed between the grid and cathode of said first mentioned amplifying tube.

2. A circuit of the character described, including; a signal source; an amplifying tube having a cathode, a grid and a plate therein; means whereby the grid of said amplifying tube is coupled to said signal source; an output circuit for the plate of said tube; a second amplifying tube coupled thereto; a diversion circuit whereby a portion of said output may be diverted; a multi-element tube having therein a cathode, a grid, a plate and two rectifying elements; means whereby the diverted portion of the signal is impressed upon the grid of said tube; means whereby the output of said last mentioned tube is coupled to both of said rectifying elements; a resistance in series with one of said rectifying elements, the voltage across said resistance being impressed between the grid and cathode of said first-mentioned tube; a squelch tube having a cathode, grid, and plate; means whereby said second rectifying element is coupled to the grid of said squelch tube; an output circuit for said squelch

tube including a resistance in series with the plate thereof; and a circuit connecting the plate of said squelch tube to the input of said second amplifying tube.

3. A circuit of the character claimed in claim 2 wherein means for varying the portion of signal diverted from said first mentioned tube is included in said diversion circuit.

4. A circuit of the character described, including; a signal source; a tube having a cathode grid and an anode therein, said grid being coupled to said signal source; an output circuit for the anode of said tube, said output circuit feeding subsequent tubes; a second circuit whereby a portion of the output of said first mentioned tube is diverted; auxiliary amplifying means having its control grid coupled to said second circuit; a plurality of rectifying means coupled to the output of said auxiliary amplifying means; a resistance in series with one of said rectifying means, the voltage developed across said resistance being impressed upon the grid of one of said first mentioned amplifying tubes; squelch tube comprising a cathode, grid, and plate; an output circuit for said squelch tube including a second resistance in series with said plate; means whereby a second of said rectifying means is coupled to the grid of said squelch tube; means comprising a third resistance in series with the cathode of said auxiliary amplifying means whereby said rectifying means are maintained at a greater negative potential with respect to said cathode than the grid of said auxiliary amplifying means; and means whereby the proportion of signal diverted may be varied.

5. A circuit of the character described, including: a signal source; a vacuum tube having a cathode, a grid and an anode therein, said grid being coupled to said signal source; an output circuit for the anode of said tube; a second circuit for said anode whereby a portion of said output may be diverted; a second tube having a cathode, a grid, and an anode therein, said grid being coupled to said second circuit; means whereby the output of said second tube is rectified; a resistance in series with said rectifying means; means whereby the direct biasing voltage developed across said resistance is impressed between the grid and cathode of said first-mentioned tube; and a second rectifying means through which a part of the output of said second tube is passed.

6. A circuit of the character described in claim 5, including a squelch tube having a cathode, a grid, and a plate therein; and means whereby said second rectifying means is coupled to the grid and cathode of said squelch tube.

7. A circuit of the character described, including: a signal source; a plurality of successive amplifying tubes operatively coupled to each other, the first of said tubes being coupled to said source; a circuit whereby a portion of the signal may be diverted to the grid of an auxiliary amplifying tube having a cathode, grid, and plate and an output circuit including said plate; means whereby the output in the plate circuit of said auxiliary amplifying tube is rectified, said means comprising cathode and anode elements; a resistance in series with one of said elements; a circuit whereby the voltage developed across said resistance is impressed on the grids of the first of said successive amplifying tubes; a second rectifying means comprising cathode and anode elements; and a circuit connecting said last mentioned elements to the plate circuit of said auxiliary amplifying tube, whereby a portion of the output of said auxiliary amplifying tube is rectified by said second rectifying means..

8. A circuit of the character claimed in claim 7, including: a squelch tube having a cathode, grid, and plate; and means coupling the grid of said squelch tube to the output of said second rectifying means.

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