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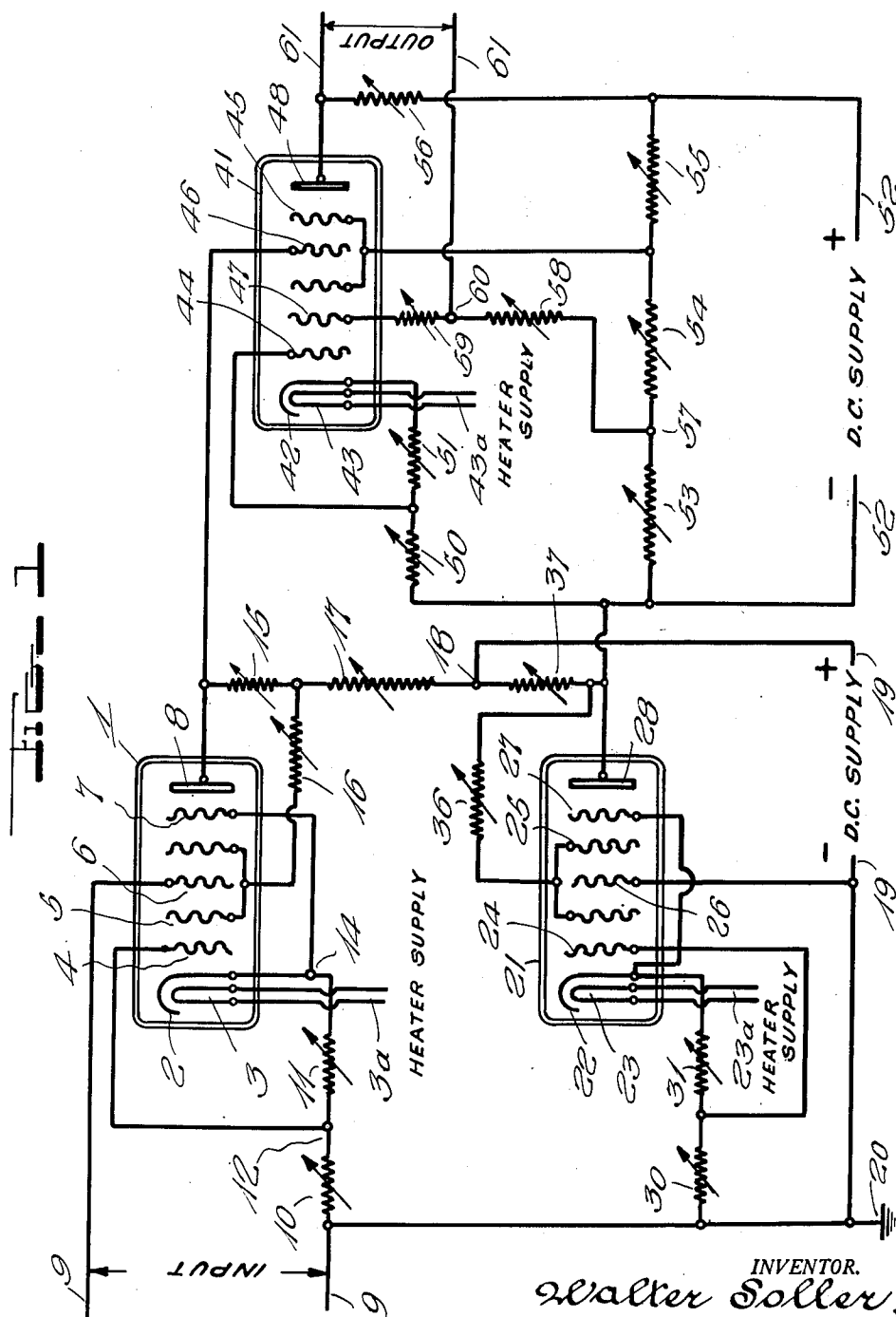
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2,392,415

BALANCED AMPLIFIER SYSTEM

Filed April 5, 1944

5 Sheets-Sheet 1



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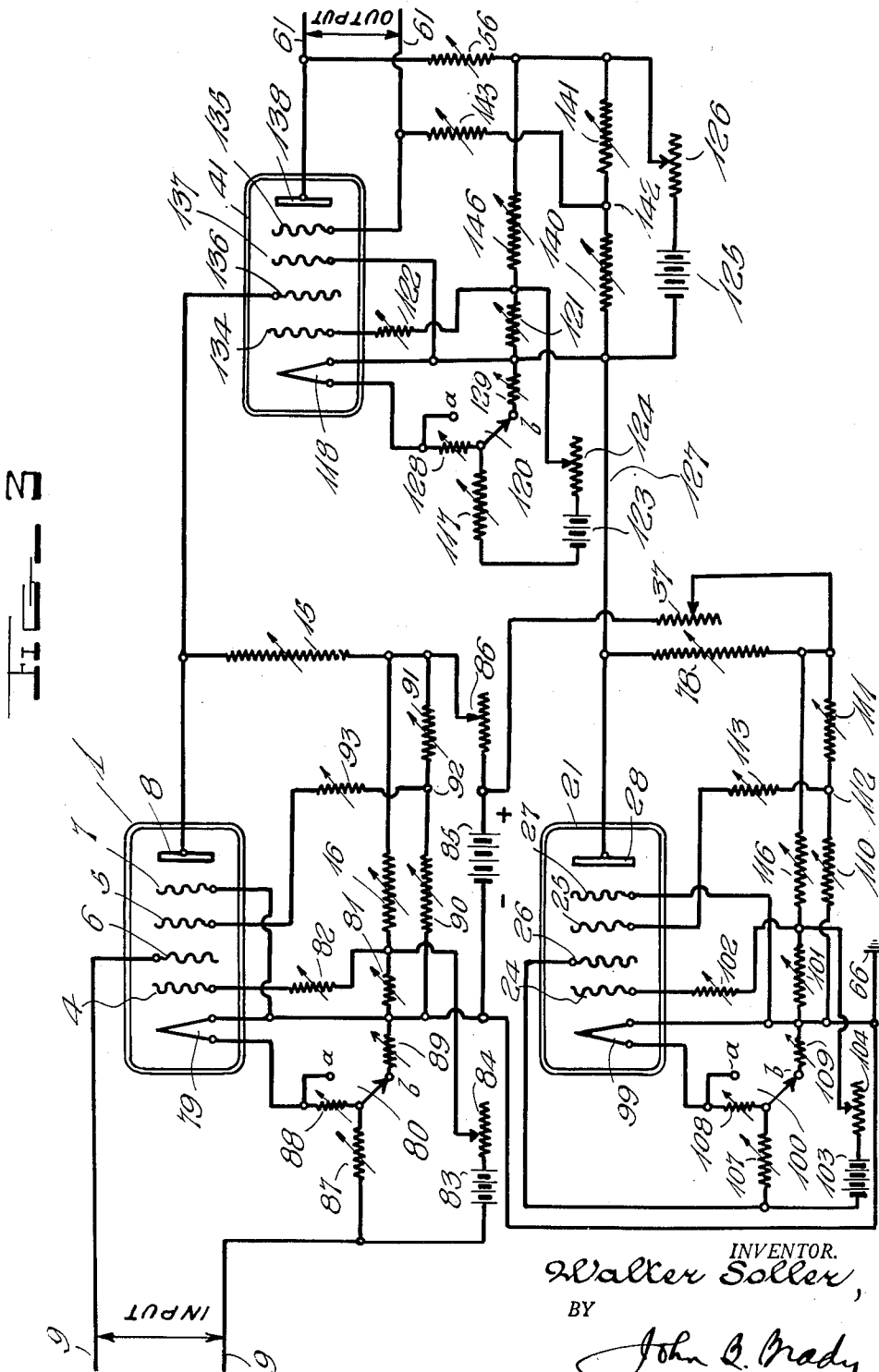
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BALANCED AMPLIFIER SYSTEM

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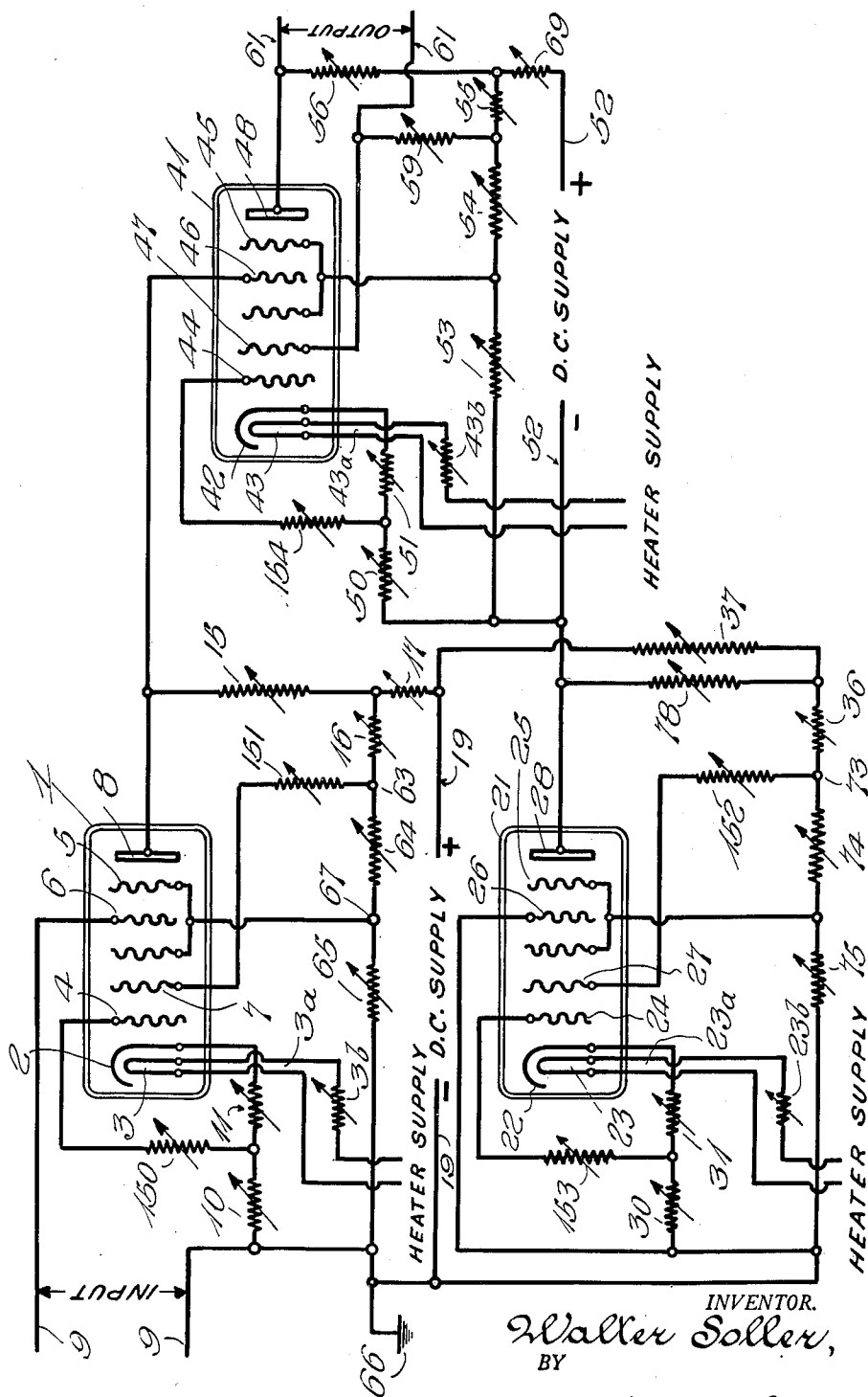
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BALANCED AMPLIFIER SYSTEM

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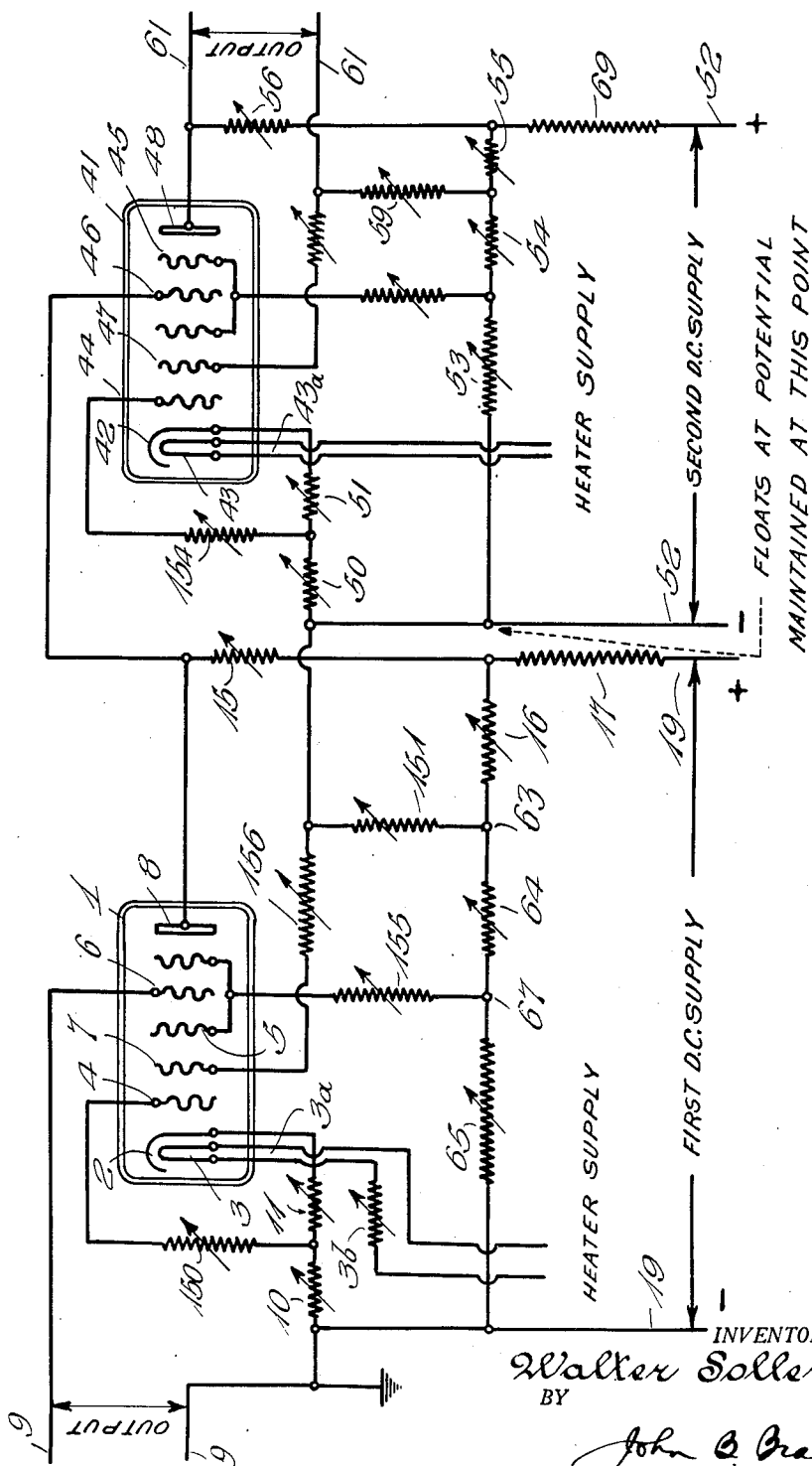
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5 Sheets-Sheet 5

FIG. 5



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2,392,415

BALANCED AMPLIFIER SYSTEM

Walter Soller, Cincinnati, Ohio, assignor of one-half to William H. Woodin, Jr., San Mateo, Calif.

Application April 5, 1944, Serial No. 529,663

10 Claims. (Cl. 179-171)

My invention relates broadly to balanced amplifier systems and more particularly to circuit arrangements for balancing multi-stage amplifier systems.

One of the objects of my invention is to provide a system for coupling multi-stage amplifier circuits involving multiple grid tubes having means for electrically balancing the circuits of each amplification stage.

Another object of my invention is to provide a multi-stage electron tube amplifier system having means in each of the stages for compensating for changes in electron emission and changes in power supply tending to vary potentials on the anode or multiple grids of the tubes in the separate stages of the amplification system.

Still another object of my invention is to provide circuit arrangements for multi-stage amplifier systems each involving a multi-grid tube having means for electrically balancing each tube and each amplifier stage for avoiding detrimental effects arising from changes in power supply voltage and electron emission in the several stages of a multi-stage amplifier system.

A further object of my invention is to provide a system for electrically balancing multi-stage electron tube amplifier systems embodying multi-grid tubes in which cathode emission is compensated in each of the stages of the amplifier system.

Still another object of my invention is to provide an arrangement of multi-stage electron tube amplifier system employing multi-grid tubes having resistance network arrangements for coupling the several stages of the amplifier in such manner that a highly stabilized condition of operation of the amplifier system is maintained.

Other and further objects of my invention reside in arrangements of resistance networks for coupling the stages of multi-grid amplifiers as set forth more fully in the specification hereinafter following by reference to the accompanying drawings, in which:

Figure 1 shows one embodiment of my invention applied to a multi-grid multi-stage amplifier system embodying my invention; Fig. 2 shows a modified form of balanced amplifier embodying my invention; Fig. 3 shows a further modified form of multi-stage amplifier circuit operating in accordance with my invention; Fig. 4 shows a still further form of multi-stage amplifier embodying my invention; and Fig. 5 shows still another arrangement of balancing system for multi-grid amplifier stages operating in accordance with my invention.

Referring to the drawings in detail, reference

character 1 designates a multi-grid tube constituting the first stage of the balanced amplifier system of my invention. Pentode tube 1 includes cathode 2 which is heated to electron emitting temperature by operation of heater 3, space charge grid 4, screen grid 5, control grid 6, auxiliary grid 7 and anode 8. The input circuit for pentode 1 is represented at 9 connected through adjustable resistances 10 and 11 with cathode 2 at one side and connected to control grid 6 at the opposite side. A tap 12 between the adjustable resistances 10 and 11 connects to the space charge grid 4 for effecting a balance of the individual circuit of pentode 1 in compensating for variations in electron emission for cathode 2. The details of this particular compensation circuit are set forth more fully in copending application Serial No. 483,351, filed April 16, 1943, by Richard P. Krebs, to which reference is made for a more complete understanding of the compensation for variation in electron emission in the individual tube circuit per se.

The auxiliary grid 7 is connected with cathode 2 through connection 14 as shown. The output from pentode 1 connects with anode 8 to one terminal of the adjustable coupling resistor 15. The opposite terminal of the adjustable coupling resistor 15 is connected through adjustable resistor 16 with the screen grid 5. The output circuit of tube 1 is then completed through adjustable resistance 17 and tap 18 to the positive side of the direct current power supply circuit that I have represented generally at 19. The negative side of the direct current power supply circuit 19 returns to the cathode 2 through adjustable resistances 10 and 11 as shown and is connected to ground at 20 as shown.

The difficulty of applying the output of tube 1 constituting one stage of amplification to the input of a succeeding tube constituting another stage of amplification is that the second stage is subjected to such relatively high potential that the operation of the second stage may become unstable. To overcome this I provide a supplemental tube circuit in the first stage of the amplifier circuit including the pentode tube shown at 21. Pentode tube 21 contains cathode 22, heater electrode 23, space charge grid 24, screen grid 25, control grid 26, auxiliary grid 27 and anode 28. The control grid 26 of pentode 21 connects directly to ground 20 as shown. Tube 21 is very carefully balanced within its own circuit through operation of adjustable resistors 30 and 31 in circuit with cathode 22 and adjustable resistors 36 and 37 in circuit with the screen grid 25 and

anode 28 as shown. The adjustable resistor 31 is arranged for compensating for variations in emission for cathode 22 under conditions of variation in the heater supply as heretofore explained in connection with pentode 1.

The second stage of amplification is represented by pentode 41 including cathode 42 heated by heater electrode 43, space charge grid 44, auxiliary grid 47, screen grid 45, control grid 46 and anode 48. The input circuit to pentode 41 connects to the terminal of adjustable resistor 15 in the output circuit of pentode 1 and to the lower terminal of adjustable resistance 37 and through adjustable resistance 17 to the lower terminal of adjustable resistance 15. The input circuit for pentode 41 includes adjustable resistors 50 and 51 arranged as shown, adjustable resistor 51 is disposed in series between cathode 42 and space charge grid 44 and serves for compensating for variations in electron emission of cathode 42 due to variations in the heater supply energy as heretofore explained. In effect, control grid 46 and cathode 42 of pentode 41 are connected to the anodes 8 and 28 of pentodes 1 and 21, respectively. The power supply for operating the amplification stage containing pentode 41 is represented at 52 across which adjustable potential divider resistors 53, 54 and 55 are connected. The cathode 42 of the pentode 41 is connected to the negative terminal of the power supply circuit 52 through adjustable resistors 50 and 51 while the anode 48 is connected with the positive terminal of the power supply circuit through adjustable resistors 56.

The tap 57 intermediate adjustable resistors 53 and 54 in the potential divider circuit connects through adjustable resistors 58 and 59 with the auxiliary grid 47. The output circuit from the second stage of amplification is connected between anode 48 and the tap 60 intermediate adjustable resistors 59 and 58 in the auxiliary grid circuit. The output circuit is shown at 61 leading to the next succeeding amplifier stage or to the current utilization stage.

The heater supply for each of the cathodes connects to the circuits represented schematically at 3a, 23a and 43a.

By the arrangement shown, the entire second stage rides at the potential of the supplemental pentode circuit 21 which is the zero balancing potential from ground of the first pentode tube circuit 1. Therefore, only the amplified input voltage remains between the control grid 46 and the negative terminal of the direct current power supply 52 of the second stage.

Fundamentally the circuit of Fig. 1 includes a Wheatstone bridge balance circuit with the additional provision for compensating for emission which by means of the additional grids 4 and 24 in tubes 1 and 21 may be accurately controlled. The resistances forming the arms of the bridge are the plate resistances of tubes 1 and 21 and the two load resistors 17 and 37. The power supply is inserted across the connection between resistors 17 and 37. As heretofore explained resistors 17 and 37 are adjustable for thereby accurately controlling the values included in the two arms of the Wheatstone bridge. The other two arms of the bridge are constituted by the electronic paths through the tubes 1 and 21 coacting with adjustable resistors 10-11 and 30-31 which terminate in the ground connection at 20 which is the opposite side of the power supply source that connects across the transverse portion of the Wheatstone bridge circuit.

The input circuit to the Wheatstone bridge at 9 connects across the control grid 6 of tube 1 and to the cathode of tube 1 through adjustable resistors 10-11, the input circuit being grounded at 20. The output circuit for the apparatus comprises the current measuring amplifier 41, the input circuit of which connects across plates 8 and 28 of tubes 1 and 21. Balance is obtained by balancing the bridge by shorting the input out and then balancing the bridge by adjusting resistors 17 and 37 until no voltage appears across plates 8 and 28. This balances and takes care of the changes in the first direct current supply voltage. The emission compensation is accomplished by adjusting resistors 10 and 11, 30 and 31, each tube independently. The second amplifier 41 is typical of the balance circuits shown in the several figures of the drawings.

In Fig. 2 I have shown a similar balancing circuit arrangement except that more precise balancing is secured by rearrangement of the circuits to the tube electrodes and the circuit elements connected with the tube electrodes. It will be observed that the circuit of tube 1 is rearranged so that balancing is effected by the auxiliary grid 7 disposed between the space charge grid 4 and the screen grid 5. The auxiliary grid 7 is connected to tap 63 in the circuit which includes adjustable resistor 16, adjustable resistor 64 and adjustable resistor 65 connected to ground 66. In this circuit path the screen grid 5 connects to tap 67 leading to ground through the adjustable resistor 65. Thus shield grid 5 is maintained at ground potential while adjustable resistor 64 controls the potential at auxiliary grid 7 and screen grid 5. A similar rearrangement is made of the electrodes in tubes 21 and 41. That is to say, a circuit path is provided from balancing resistor 36 through balancing resistor 74 and balancing resistor 75 to the negative side of the power supply source 52 and tap connections are taken from point 73 intermediate adjustable resistors 36 and 74 to the auxiliary grid 27 of tube 21 and from tap 77 intermediate adjustable resistors 74 and 75 to screen grid 25 arranged in the order explained with respect to tube 1. Additional balancing is obtained by the inclusion of adjustable resistor 78 in circuit with plate electrode 28.

Tube 41 shown in Fig. 2 corresponds to the tube described in connection with Fig. 1 and contains the same elements except that the elements are arranged in the order heretofore explained for the elements of tubes 1 and 21 in Fig. 2. The input circuit for tube 41 in Fig. 2 extends from control grid 46 to the upper terminal of adjustable resistance 15 and from the cathode 42 through adjustable resistors 51 and 50 to the anode 28 of tube 21. For further balancing the circuit of tube 41 with greater precision, I provide adjustable resistors 68 and 69 arranged in circuit with anode 48 and auxiliary grid 47 as shown.

Each of the filament heating circuits are provided with adjustable rheostats 3b, 23b and 43b in circuit with the heater supply, as shown. Precision balancing is obtained by adjusting the resistors shown and amplification is effected under stabilized conditions despite the fact that a high potential is impressed upon the input circuit of the second stage. The supplemental tube circuit 21 operates to maintain the second stage constituted by tube 41 at a constant potential irrespective of substantial variations in the power supply.

I may apply the principles of my invention to 75 tubes of the directly heated type, as shown in

Fig. 3 in which tube elements numbered to correspond with similar tube elements, described in connection with Figs. 1 and 2, are shown in association with a directly heated cathode. That is to say, tube 1 contains a directly heated cathode 79 associated with the space charge grid 4, the control grid 6, the screen grid 5, the suppressor or auxiliary grid 7 and the anode 8. The balanced circuits associated with the electrodes of tube 1 are generally similar to the circuits heretofore explained in that the input circuit 9 connects to the control grid 6 and the cathode 79 through the switch circuit 80. For a further explanation of the switch circuit 80, reference is made to my Letters Patent 2,245,616, granted June 17, 1941, for Amplification system. The switch circuit 80 includes a switch arm that is movable to either position *a* or position *b*. In position *a* the switch arm short circuits the adjustable series resistance 88 in the filament or heater circuit while in the position *b* the switch arm serves to introduce adjustable resistance 89 in a shunt path with the filament 79. Thus the emission of the cathode 79 can be changed independently of the power source, which I have represented at 83 connected through adjustable rheostat 84 with the adjustable resistor 87 leading to one side of the cathode circuit terminating in the switch system 80 and through adjustable resistance 81 to the other side of the cathode circuit as shown.

The space charge grid 4 is connected through adjustable resistor 82 with the cathode circuit for compensating for variation in cathode emission.

An independent source 85 is provided for energizing the other elements of the tube through adjustable resistance 86 as shown. A potentiometer or divider circuit is provided for applying selected potentials to the tube elements as represented at 90 and 91 connected across the power supply circuit energized from source 85. Tap 92 provides a connection through adjustable resistor 93 to screen grid 5. Adjustable resistance 16 connects between the space charge grid 4 and the positive side of the power source 85 through adjustable resistance 86, as shown. The output is delivered to adjustable resistance 15 from which connection is taken to the input circuit of the next succeeding stage of amplification embodying tube 41.

The emission from cathode 79 is maintained constantly under conditions of variation in the applied power from source 83 or under conditions of other variations by adjusting resistors 87, 81 and 82 until no change occurs in the emission when both switch 80 is thrown from position *a* to position *b* and resistor 84 is adjusted. Proportional adjustments are made in the adjustable resistances in circuit with the other elements of the tube as explained in detail in my Patent 2,245,616 supra.

In order to maintain a constant potential at the second stage of the amplifier constituted by tube 41, I provide a supplemental tube 21 which corresponds with a correspondingly numbered supplemental tube 21 illustrated in Figs. 1 and 2 except for the rearrangement of electrodes and the inclusion of the directly heated cathode in lieu of the indirectly heated cathode illustrated in Figs. 1 and 2. Referring to tube 21 in detail, I have shown the directly heated cathode 99 arranged in a power supply circuit for obtaining constant emission of the same type described in connection with tube 1, that is a switching device 100 is provided, movable to either position *a* or posi-

tion *b* for controlling the connection of the cathode circuit with the power source 103 through adjustable rheostat 104 and adjustable resistors 101 and 107 with the switching device 100. The switching device 100 controls the circuit through the adjustable resistors 108 and 109 for setting the cathode circuit for constant emission. This is accomplished by adjusting resistors 107, 101, and 102 until no change occurs in the emission when both switch 100 is thrown from position *a* to position *b* and resistor 104 is adjusted. The other tube elements are energized in a manner similar to the arrangement described in connection with tube 1, that is anode 28 connects through adjustable resistance 78 to the positive side of the power source 85 through adjustable rheostat 37. The negative side of power source 85 terminates at the cathode 99 and is grounded at 86 as shown. The control grid 26 completes a path to the input circuit of the tube through adjustable resistance 107 as shown. The space charge grid 24 operates to compensate for variations in emission by adjustment of resistance 102. A balance is effected on screen grid by control of adjustable resistance 113. The required potentials for operating the anode circuit are determined by adjustment of resistors 110 and 111. The tap 112 leads through adjustable resistor 113 to screen grid 25. The adjustable resistance 115 determines the potential between the space charge grid 24 and the anode 28. Tube 21 when adjusted holds the second stage, constituted by tube 41, at a constant potential. Tube 41, as in the case of tubes 1 and 21, includes elements corresponding to the elements as in Fig. 2 except that a directly heated cathode is employed. The cathode is shown at 118 arranged for constant emission under control of a power supply source similar to that described in connection with tubes 1 and 21. That is a power supply source indicated at 123 is connected through an adjustable rheostat 124 to opposite sides of the cathode circuit through adjustable resistor 117 to switch system 120, movable either to position *a* or position *b* to effectively include or exclude resistances 129 or 128 in the cathode circuit. The energy supplied to the cathode circuit passes through adjustable resistance 121 to one terminal of which the adjustable resistance 122 connects leading to the space charge grid 134. By adjusting resistor 122, compensation for variation in electron emission may be effected. One side of the cathode circuit connects through lead 127 to the plate electrode 28 of supplemental tube 21 while the control grid 136 connects to the terminal of adjustable resistor 15 that connects to plate electrode 8. High potential under conditions of great stability is impressed between control grid 136 and the cathode circuit as shown. A connection is taken from suppressor or auxiliary grid 137 to the cathode 118. The output circuit connects between anode 138 and the screen grid 135 as shown. The power supply system for the elements of the tube as just described is completed from source 125 through adjustable rheostat 126 to the potentiometer and divider circuit represented by resistors 140 and 141. Tap 142 connects through adjustable resistor 143 to the screen grid 135 for applying the required potential thereto. Adjustable resistance 56 is arranged in the anode circuit in connection with anode 138 as shown. Adjustable resistance 146 determines the potential across space charge grid 134 and anode 138.

A high degree of stabilized amplification is thus

obtained by effecting the adjustment shown for amplification of feeble currents despite the high potential existent across the input of the second stage of amplification.

In Fig. 4 I have shown a modified circuit arrangement arranged for accomplishing the objects obtained in the previous forms of the circuit of my invention but having a further degree of precision combination for variation in electron emission. In Fig. 4 I provide for additional compensation for electron emission by including a further adjustable resistor 150 interposed between the space charge grid 4 and the circuit leading to the cathode 2 through adjustable resistor 11. In tube 1 I provide for additional balancing of the auxiliary grid 7 by means of adjustable resistor 151. The power supply for the other elements of the tube is secured by an arrangement of resistors 16, 64 and 65 similar to that set forth in Fig. 2. Similarly the supplemental tube 21 has the elements thereof arranged as explained in connection with the circuit of Fig. 2 with the additional precise balancing obtained by the provision of adjustable resistor 152 connected to tap 73 in the potential divider circuit which includes adjustable resistors 75, 74 and 36, as shown. Variations in electron emission for tube 21 are adjusted with a high degree of precision by means of adjustable rheostat 153.

The plate circuit of supplemental tube 21 connects to the cathode system of the tube 41 constituting the second stage of amplification. Provision is made for the compensation of variations in electron emission in a manner similar to that explained in connection with tubes 1 and 21, that is by the arrangement of adjustable resistance 154 disposed in circuit between the space charge grid 44 and the cathode 42 as shown.

The energization for the other elements of tube 41 is obtained in a manner similar to the arrangements heretofore explained so that an amplified output is delivered at 61 under conditions of great stability.

In Fig. 5 I have shown a further improvement in the amplification system embodying my invention in which the pentodes 1 and 41 constituting the first and second stages of the amplifier system are coupled without the aid of the supplemental tube circuit heretofore explained. The separate tubes 1 and 41 in Fig. 5 are individually balanced. This arrangement is radically different from the coupled circuits of my Patent 2,245,616 supra. In the circuits disclosed in that patent part of the cathode current of the second stage tube goes through resistances of the circuit of the first stage. Therefore, changes in the second stage cathode current, due to power supply, voltage and emission changes, will affect the output of the first stage. The compensation for these changes in the first stage are then taken care of in the balancing of the second stage. That is, the balancing of the two stages are not independent of each other.

In Fig. 5 the circuit arrangement is such that not only each stage but each type of variation, the voltage on the elements and the emission, is balanced independently.

In the circuit of Fig. 5 the entire second stage floats with respect to the first stage.

Variations in emission and voltages due to the changes in power supply voltage of the first stage are compensated for in such a way that they will not appear in the voltage between the control grid and connection between resistors 50 and 53. Voltage above ground of this latter connection

will vary with the power supply. By arranging the second direct current supply so that it is insulated completely from ground, this connection between resistors 50 and 53 will continually take on the voltage of the first stage without ever affecting the input voltage on the second stage.

In the circuits shown in Figs. 1-4, the second stage is held at a definite voltage, that is, the voltage maintained by the supplemental tube circuit of the first stage constituted by tube 21.

The major compensation for emission change is accomplished independently of the compensation of voltage changes making complete balancing of the system easier of accomplishment.

The electrodes of tubes 1 and 41 are arranged as explained in Figs. 2 and 4 with similar circuit elements. Provision is made however for independently balancing the circuit to the screen grid 5 by means of adjustable resistor 155 connected to tap 67 in the potentiometer or divider circuit containing resistors 16, 64 and 65. Independently adjustable balancing resistor 155 is connected between tap 63 in the same circuit and the auxiliary grid 7 with the additional adjustable resistor 156 disposed in series therewith as shown for effecting precision balancing of the first stage. This circuit will also function with some tubes when grids 4 and 44 are directly connected to the connection between resistors 10 and 11 or 50 and 51.

In reviewing the several figures of the drawings, it will be seen that the first stage of amplification in Figs. 1-4 is constituted by the pentode 1 including its cathode and anode and multiplicity of cold grid electrodes in association with the supplemental tube 21 having the cathode and anode thereof connected in multiple with the cathode and anode of the tube 1. The output circuits of each of these tubes 1 and 21 in multiple connect to the control and cathode of the tube 41. In effect the anode of tube 1 connects to the control grid of tube 41 while the anode of tube 21 connects to the cathode of tube 41. In Fig. 1 additional balance is obtained by an adjustable resistor disposed in circuit with the screen grid electrodes. In Fig. 2 additional balancing is obtained by an adjustable resistor disposed in circuit with the auxiliary grid electrode. In Fig. 3 additional balancing is obtained by including adjustable resistors in the control grid circuits of the several tubes, together with independently adjustable resistors in the screen grid circuits thereof. In Fig. 4 additional balancing is obtained by including adjustable resistors in the auxiliary grid circuits, at the same time including additional adjustable resistors in each of the control grid circuits. In Fig. 5 wherein the separate stages are individually balanced, precision balancing is obtained by including independently adjustable resistors in series with the screen grid electrodes, the auxiliary grid electrodes, as well as the control grid electrodes.

The circuits embodying my invention are shown in their general form. It is understood that any resistor shown in these circuits can have a resistance of zero ohms, if it is found that this condition is required for balance or correct compensation. One or up to three of the resistors, 150, 151, 154, 155, 156 may have zero ohms.

The circuit arrangements of my invention have proven highly practical in operation and while I have explained my invention in certain preferred embodiments, I desire that it be understood that modifications may be made and 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. A stabilized amplification system comprising a plurality of electron tubes each including a cathode, a space charge grid, a control grid, a screen grid, an auxiliary grid and anode electrodes, a power supply circuit for energizing said electrodes, circuits individual to the electrodes of each of said tubes, means for electrically balancing the circuits of each of said tubes constituting separately balanced stages, one of said stages including a pair of said tubes with the cathode and anodes thereof connected in multiple and another of said stages including another of said tubes with the control grid electrically connected with the anode of one of said pair of tubes and the cathode electrically connected with the anode of the other of said tubes in said pair of tubes, and an output circuit connected between the anode and auxiliary grid of the tube in said last mentioned stage.

2. A stabilized amplification system comprising a plurality of electron tubes each including a cathode, a space charge grid, a control grid, a screen grid, an auxiliary grid and anode electrodes, a power supply circuit for energizing said electrodes, circuits individual to the electrodes of each of said tubes, means for electrically balancing the circuits of each of said tubes constituting separately balanced stages, certain of said tubes including independently adjustable means in circuit with the screen grid electrodes thereof, one of said stages including a pair of said tubes with the cathode and anodes thereof connected in multiple and another of said stages including another of said tubes with the control grid electrically connected with the anode of one of said pair of tubes and the cathode electrically connected with the anode of the other of said tubes, and an output circuit connected between the anode and auxiliary grid of the tube in said last mentioned stage.

3. A stabilized amplification system comprising a plurality of electron tubes each including a cathode, a space charge grid, a control grid, a screen grid, an auxiliary grid and anode electrodes, a power supply circuit for energizing said electrodes, circuits individual to the electrodes of each of said tubes, means for electrically balancing the circuits of each of said tubes constituting separately balanced stages, one of said stages including a pair of said tubes with the cathode and anodes thereof connected in multiple and another of said stages including another of said tubes with the control grid electrically connected with the anode of one of said pair of tubes and the cathode electrically connected with the anode of the other of said tubes in said pair of tubes, and an output circuit connected between two of the electrodes of the tube in said last mentioned stage.

4. A stabilized amplification system comprising a plurality of electron tubes each including a cathode, a space charge grid, a control grid, a screen grid, an auxiliary grid and anode electrodes, a power supply circuit for energizing said electrodes, circuits individual to the electrodes of each of said tubes, means for electrically balancing the circuits of each of said tubes constituting separately balanced stages, certain of said tubes including independently adjustable means in circuit with the screen grid electrodes thereof, one of said stages including a pair of said tubes

with the cathode and anodes thereof connected in multiple and another of said stages including another of said tubes with the control grid electrically connected with the anode of one of said pair of tubes and the cathode electrically connected with the anode of the other of said tubes in said pair of tubes, and an output circuit connected between two of the electrodes of the tube in said last mentioned stage.

5. A stabilized amplification system comprising a plurality of electron tubes each including a cathode, a space charge grid, a control grid, a screen grid, an auxiliary grid and anode electrodes, a power supply circuit for energizing said electrodes, circuits individual to the electrodes of each of said tubes, means for electrically balancing the circuits of each of said tubes constituting separately balanced stages, independently adjustable means in circuit with the auxiliary grid in each of said tubes, one of said stages including a pair of said tubes with the cathode and anodes thereof connected in multiple and another of said stages including another of said tubes with the control grid electrically connected with the anode of one of said pair of tubes and the cathode electrically connected with the anode of the other of said tubes in said pair of tubes, and an output circuit connected between two of the electrodes of the tube in said last mentioned stage.

6. A stabilized amplification system comprising a plurality of electron tubes each including a cathode, a space charge grid, a control grid, a screen grid, an auxiliary grid and anode electrodes, a power supply circuit for energizing said electrodes, circuits individual to the electrodes of each of said tubes, means for electrically balancing the circuits of each of said tubes constituting separately balanced stages, means associated with the cathodes of each of said tubes for maintaining constant electron emission therefrom, one of said stages including a pair of said tubes with the cathode and anodes thereof connected in multiple and another of said stages including another of said tubes with the control grid electrically connected with the anode of one of said pair of tubes and the cathode electrically connected with the anode of the other of said tubes in said pair of tubes, and an output circuit connected between two of the electrodes of the tube in said last mentioned stage.

7. A stabilized amplification system comprising a plurality of electron tubes each including a cathode, a space charge grid, a control grid, a screen grid, an auxiliary grid and anode electrodes, a power supply circuit for energizing said electrodes, circuits individual to the electrodes of each of said tubes, means for electrically balancing the circuits of each of said tubes constituting separately balanced stages, means associated with the cathodes of each of said tubes for maintaining constant electron emission therefrom, independently adjustable means in circuit with each of said auxiliary grids for balancing each of said stages in said auxiliary grids, one of said stages including a pair of said tubes with the cathode and anodes thereof connected in multiple and another of said stages including another of said tubes with the control grid electrically connected with the anode of one of said pair of tubes and the cathode electrically connected with the anode of the other of said tubes in said pair of tubes, and an output circuit connected between two of the electrodes of the tube in said last mentioned stage.

8. A stabilized amplification system comprising

a plurality of electron tubes each including a cathode, a space charge grid, a control grid, a screen grid, an auxiliary grid and anode electrodes, a power supply circuit for energizing said electrodes, circuits individual to the electrodes of each of said tubes, means for electrically balancing the circuits of each of said tubes constituting separately balanced stages, an adjustable resistor interposed between said space charge grid and said cathode for compensating for variations in electron emission from said cathode, one of said stages including a pair of said tubes with the cathode and anodes thereof connected in multiple and another of said stages including another of said tubes with the control grid electrically connected with the anode of one of said pair of tubes and the cathode electrically connected with the anode of the other of said tubes in said pair of tubes, and an output circuit connected between two of the electrodes of the tube in said last mentioned stage.

9. A stabilized amplification system comprising a plurality of electron tubes each including a cathode, a space charge grid, a control grid, a screen grid, an auxiliary grid and anode electrodes, a power supply circuit for energizing said electrodes, circuits individual to the electrodes of each of said tubes, means for electrically balancing the circuits of each of said tubes constituting separately balanced stages, one of said stages including a pair of said tubes with the cathode and anodes thereof connected in multiple and another of said stages including another of

said tubes with the control grid electrically connected with the anode of one of said pair of tubes and the cathode electrically connected with the anode of the other of said tubes in said pair of tubes, an output circuit connected between the anode and auxiliary grid of the tube in said last mentioned stage, and an adjustable resistor in said last mentioned connection for further balancing the operation of said circuits.

10. A stabilized amplification system comprising a plurality of electron tubes each including a cathode, a space charge grid, a control grid, a screen grid, an auxiliary grid and anode electrodes, a power supply circuit for energizing said electrodes, circuits individual to the electrodes of each of said tubes, means for electrically balancing the circuits of each of said tubes constituting separately balanced stages, one of said stages including a pair of said tubes with the cathode and anodes thereof connected in multiple and another of said stages including another of said tubes with the control grid electrically connected with the anode of one of said pair of tubes and the cathode electrically connected with the anode of the other of said tubes in said pair of tubes, an output circuit connected between the anode and auxiliary grid of the tube in said last mentioned stage, an adjustable resistor in said last mentioned connection for further balancing the operation of said circuits, and independently adjustable means in circuit with each of the screen grid electrodes of said electron tubes.

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