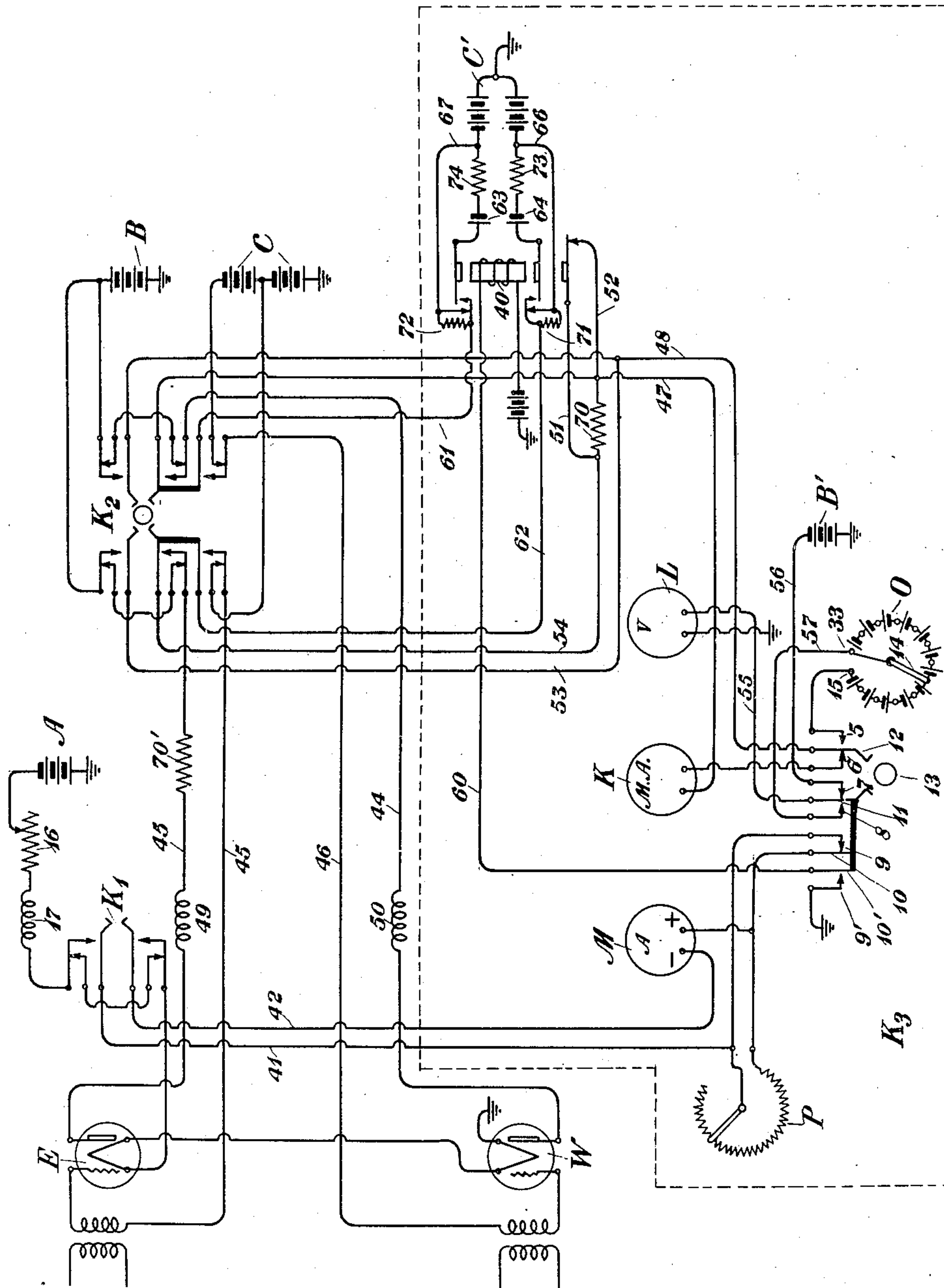


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TELEPHONE REPEATER EQUIPMENT

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By their Attorney *g r y o n*

UNITED STATES PATENT OFFICE.

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TELEPHONE REPEATER EQUIPMENT.

Application filed March 18, 1921. Serial No. 453,312.

To all whom it may concern:

Be it known that we, GEORGE CRISSON and SAMUEL P. SHACKLETON, residing at Hackensack and Wyoming, in the counties of Bergen and Essex and State of New Jersey, respectively, have invented certain Improvements in Telephone Repeater Equipments, of which the following is a specification.

This invention relates to improvements in electron tube testing arrangements.

In U. S. Patent No. 1,365,734, issued January 18, 1921, in the name of Samuel P. Shackleton and entitled Electron tube testing circuits, there is disclosed a circuit arrangement for testing electron tubes to which the arrangements embodied in this invention are applicable. With the arrangements disclosed in the above entitled application the electron tubes, which are suitable for use as repeaters for telephone currents, may be subjected to two distinct tests. The first test is to ascertain whether the tube is operating within certain prescribed limits of current and voltage and is made by inserting appropriate meters in the filament and plate circuits of the tubes. The second test which may be made with these arrangements is for the purpose of ascertaining whether the condition of the tubes is such as to warrant their replacement. For this test the voltage on the plate is adjusted to a predetermined value and the filament current is lowered to such an extent that the consequent reduction in the electron discharge causes a reduction in the plate current and consequently affects the amplification value of the tube. The value of the plate current under these conditions is noted and, if below a predetermined minimum, the tube is discarded and another one substituted.

It has been found that the arrangements of the above mentioned application will operate satisfactorily in subjecting the tubes of a repeater set to the second type of test when the tubes are provided with separate sources of grid, or "C", potential. However when the test is applied to determine the condition of tubes in a repeater circuit which are provided with a common source of grid, or "C", potential, a source of difficulty is

encountered in the fact that the reduction in the filament current alters the potential of the filaments with respect to ground and so changes to a serious extent from the normal the potential difference between the filaments and grids existing at the time of the test. In other words at the time of the test there will exist a voltage difference between the grid and filament which will be greater than that under which the tubes are designed to operate under actual service conditions. This change tends to reduce the space current by a greater amount than the change of filament current alone would reduce it and leads to premature rejection of tubes. It furthermore will cause the test to be made under abnormal conditions rather than under actual service conditions as desired. Accordingly it is an object of this invention to provide arrangements in the testing or metering circuit which, when tubes of a repeater set having a common source of grid potential are subjected to test, will operate to compensate for any potential variations between grid and filament which might result from the step of lowering the filament current. Accordingly with the arrangements of this invention such tubes may be tested under conditions more nearly approximating actual service conditions. Other objects and features of the invention will appear more fully from the detailed description hereinafter given.

This invention may be more fully understood from the following description considered in connection with the accompanying illustrative drawing which shows one embodiment thereof.

In the drawing reference characters E and W designate two electron tubes which are interconnected through a two-way two-element repeater circuit not shown on the drawing. This circuit may, if desired, be of the type illustrated in the U. S. Patent No. 1,436,683, November 28, 1922, to Arthur F. Rose, for battery supply circuits for repeaters. Reference character K designates a milli-ammeter provided for indicating the plate current in either tube E or W. L is a voltmeter for determining the voltages of

batteries A and B and M is an ammeter for determining the current in the filaments of both tubes. O is a source of variable potential which may comprise a number of dry cells connected in series, the terminals of each cell being connected to contact points which are in cooperative relation with a pivoted contact arm 14. Terminals 33 and 15 of source O are connected, respectively, to arm 14 and to a terminal of one of the intermediate dry cells for purposes which will be pointed out later. Where desired other sources of variable potential may be used. K_3 is a switch comprising blades 10, 11 and 12 which in the position shown (herein termed for convenience the normal position) close against contact points 9, 7 and 6 respectively. When the switch K_3 is reversed by operation of the handle indicated at 13, contact with points 9, 7 and 6 is broken and blade 11 makes contact with point 8 and blade 12 closes against contact 5. An additional blade 10' is provided which, when handle 13 is operated, closes against contact 9'.

P is a rheostat of variable resistance which is at times included in the filament circuit as described hereinafter. K_1 is a switch associated with the filament circuits of the tubes and K_2 is a switch associated with the plate circuits of the tubes. The relay 40 and circuit arrangements associated therewith are the arrangements for compensating for the potential variations, which take place, when the filament current is arbitrarily reduced, as will be pointed out hereinafter.

The apparatus above described is controlled by the following circuits:

The filaments of tubes E and W are connected in series in a circuit extending from ground, battery A, resistance 16, inductance 17, break contacts of switch K_1 , filament of tube E, filament of tube W, through ground back to battery A. The space currents for the tubes are supplied from battery B, the circuit for the plate of tube W comprising the right-hand break contacts of switch K_2 , the conductor 44, and the inductance 50, and the circuit for tube E comprising the left-hand break contacts of switch K_2 , and the conductor 45 which includes a resistance element and the inductance 49. These circuits are substantially the same, except for switches K_1 and K_2 , as those shown in the above mentioned copending application in the name of Arthur F. Rose and reference may be had thereto for a further description thereof. The grid circuit for the tubes extends from the common C battery, over the lower break contacts of switch K_2 , and thence over conductors 45 and 46 to the grids of the tubes.

The circuit for ammeter M is from the upper make contact of switch K_1 , conductor

41, contacts 9—10 of switch K_3 , ammeter M, conductor 42, to the lower make contact of switch K_1 . When the switch K_3 is thrown it opens contact 9—10 so that the ammeter circuit is then through the adjustable rheostat P. When switch K_1 is thrown it connects the ammeter M into the formerly described filament circuit. Resistance P being normally short circuited causes a reduction in the filament current only when the switch K_3 is thrown. The ammeter M may thus be utilized to measure the filament current of the tubes.

The circuit for the milli-ammeter K may extend from the upper right-hand make contact of switch K_2 , conductor 48, contacts 12—6 of switch K_3 , milli-ammeter K, conductor 47, to the middle right-hand make contact of switch K_2 . The milli-ammeter circuit might also extend from conductors 47 and 48 to the left-hand upper and middle make contacts of switch K_2 , over conductor 53 and over conductors 54, 51, 52 and the lower armature of relay 40. By throwing the switch K_2 to the right or left it is thus possible to cause the space current of either tube to flow through the milli-ammeter K, whereby the value of said current may be indicated.

When, however, the switch K_3 is thrown contact 12—6 of the previously traced milli-ammeter circuit will be opened and the milli-ammeter circuit will be completed as follows: from conductor 48, contact 12—5 of switch K_3 , terminal 15 of source O, through a portion of source O, contact arm 14, terminal 33, conductor 57, milli-ammeter K, to conductor 47. In other words the throwing of switch K_3 will connect in series with battery B a portion of the source O, so that the voltage applied to the plate can be adjusted to its normal value.

The voltmeter L may be utilized to ascertain the voltage of the B battery and is herein shown as directly connected to said battery, said battery being represented by B', by conductor 56, contact 7—11 of switch K_3 , conductor 55, voltmeter L, to ground.

If it is desired to test one of the tubes, such as the tube W, to determine whether its condition is such as to warrant its continued use, the procedure is as follows: The switch K_2 will be thrown to the right and switch K_3 will also be operated. The operation of switch K_2 will connect the milli-ammeter K into the plate circuit of the tube. The operation of switch K_3 will include in series with the battery B in the plate circuit the source O. The contact arm 14 will now be adjusted until the plate voltage of battery B is of a predetermined value which will be indicated by the volt-ammeter L. The switch K_1 will now be operated. As the switch K_3 had previously been operated the operation of switch K_1 will

include in the filament circuit the rheostat P. The rheostat P will now be operated and the filament current reduced until the ammeter M indicates the current with which it is desired to make the test. The milliammeter K is then read and if the plate current indicated thereby is not below a predetermined minimum its condition is such as to warrant its continued use. However if the tube fails to give the desired plate current under these test conditions it is discarded and a new tube substituted therefor.

It is pointed out that when switch K_2 is thrown to the right in making this test that the previously traced grid circuit for tube W is opened at the lower right-hand break contact of switch K_2 and the grid circuit is now completed as follows: from grid of tube W, conductor 46, lower right-hand make contact of switch K_2 , conductor 61, break contact of relay 40, conductor 67, to the usual grid battery herein termed C' , to ground. However when the switch K_3 is operated for test purposes the following circuit will be closed: from ground, contact 9'—10' of switch K_3 , conductor 60, winding of relay 40, to battery and ground, thereby operating relay 40. The operation of relay 40 will allow the grid circuit for tube W to be completed from conductor 61 as follows: from conductor 61, make contact and armature of relay 40, battery 63 and a resistance 74, to battery C' and ground. A second resistance 72 is placed in circuit around the battery 63 and resistance 74 for a purpose more fully described later on. The battery 63 is thus connected in series with battery C' but is oppositely poled thereto and accordingly will reduce the voltage applied to the grid circuit by battery C' . Accordingly by regulating the battery 63 the voltage of the grid circuit may be reduced to a desired degree to compensate for any changes in potential between grid and filament which would take place otherwise when the filament current was reduced by the rheostat P in making the test.

In a similar manner when the switch K_2 is thrown to the left the formerly traced grid circuit for tube E is opened and completed over the lower left-hand make contact of switch K_2 , conductor 62, lower middle break contact of relay 40, and conductor 66, to battery C' . When the switch K_3 is operated the relay 40 upon operating will cause said circuit to be completed from conductor 62 as follows: from conductor 62, lower middle make contact and armature of relay 40, battery 64 and a resistance 73, to battery C' and ground. The battery 64 is oppositely poled to battery C' and will thus serve to reduce the voltage applied to the grid circuit when the filament current is reduced in making the test and will thus compensate for any changes in potential be-

tween grid and filament which would take place otherwise upon the aforesaid reduction in filament current.

A further feature of the arrangements of the invention consists in the association with the plate circuit of the tube E in the metering arrangements of a resistance 70. This resistance is normally short circuited by conductors 51 and 52 and the lower break contact of relay 40 and is cut into the plate circuit upon the operation of relay 40. This resistance will thus be added to the usual compensating resistance 70' in the plate circuit so that under the critical test conditions, namely when the space current has the limiting value which determines whether a tube is to be rejected or retained in service, the potential difference between filament and plate of both tubes will remain the same. The testing operation for tube E would be substantially similar to that for tube W.

For purposes of further illustrating the invention let it be assumed that under normal operating conditions e_1 represents the grid voltage of the tube W, e_2 represents the grid voltage of tube E, e_3 represents the filament voltage of tube W, and e_4 represents the filament voltage of tube E. Let I be the normal filament current. Then when $I=1.25$ amperes $e_3=-6$ volts, $e_4=-12$ volts, and conditions are maintained so that $e_1=-15$ volts, $e_2=-21$ volts. In each case the potential difference between filament and grid will then be e_1-e_3 or e_2-e_4 which will be -9 volts, which is the proper potential difference for normal operating conditions. If the filament current I is then reduced for testing purposes to 1.1 amperes and the compensating arrangements of this invention are not employed then under such conditions $e_1=-15$, $e_3=-5.3$, $e_2=-21$, $e_4=-10.6$, and the potential drop between grids and filaments will be other than -9 volts. Accordingly the values assignable to the compensating batteries 63 and 64 should be such that $e_1=-14.3$, $e_3=-5.3$, $e_2=-19.6$, $e_4=-10.6$. In other words battery 63 should reduce the voltage applied by battery C' to the grid of tube W by .7 volts and battery 64 should reduce the voltage applied to the grid of tube E by 1.4 volts. It is pointed out that these values are not arbitrary but are merely illustrative of the principles of operation of the invention.

It may readily occur that the desired values of e_1 and e_2 for test conditions may not be obtained by a whole number of cells in batteries 63 and 64. For this reason resistances 71 and 72, hereinbefore referred to, are added such that only a portion of the battery potential is used to oppose the voltage of C' , as follows: Current from battery 63 flows through resistances 72 and 74 during test conditions and the potential of the battery is divided across the two in propor-

tion to the values of resistance. This may be more readily seen from a consideration of the circuit when relay 40 is in its operated condition. The potential across resistance 5 72 is

$$E_{72} = \frac{R_{72}}{R_{72} + R_{74}} E_{63}$$

where R_{72} = value of resistance 72, R_{74} = value of resistance 74, E_{63} = voltage of battery 63. Since no current flows from battery C', the potential impressed on the grid of tube W is the voltage of C' minus the drop across resistance 72. Similarly the 15 grid potential of tube E will be the voltage of battery C' minus the drop across resistance 71. It will be understood that resistances 71, 72, 73 and 74 will be so proportioned as to give the desired values of grid 20 potential with batteries 63 and 64.

While the invention has been disclosed as embodied in certain specific arrangements, which have been deemed desirable, it is understood that it is capable of embodiment in 25 other and widely varied forms without departing from the spirit of the invention as defined in the appended claims.

What is claimed is:

1. In combination, an electron tube, a 30 plate circuit, filament circuit and a grid circuit associated therewith, means for adjusting the current in the filament circuit, means for adjusting the voltage in the plate circuit, means for adjusting the voltage in the grid circuit, and a device for simultane- 35 ously connecting said adjusting means into said circuits.

2. In combination, an electron tube, a filament circuit associated therewith and including a current measuring device, a plate 40 circuit associated with said tube and including voltage and current measuring devices, a grid circuit associated with said tube, a voltage varying device associated with said 45 grid circuit, a variable resistance, a source

of variable electromotive force, and a switch for simultaneously connecting said variable resistance into said filament circuit and said source of variable electromotive force into said plate circuit and said voltage varying 50 device into said grid circuit.

3. In combination, an electron tube, a filament circuit, a plate circuit, a grid circuit, means for at times reducing the flow of current in said filament circuit below normal, 55 means for at times correcting the voltage in said plate circuit, means for at times correcting the voltage in said grid circuit, and a device for simultaneously introducing said reducing means into said filament circuit 60 and said first mentioned correcting means into said plate circuit and said second mentioned correcting means into said grid circuit.

4. In combination, a plurality of electron 65 tubes, each comprising filament, plate, and grid electrodes, an energizing circuit for said filaments, said filaments being serially included therein, a circuit for applying 70 voltages to said grid electrodes, an energizing circuit for said plates, means in said last mentioned circuit to compensate for the normal difference between the plate-filament voltages of the two tubes due to the series 75 connection of the filaments, means for adjusting the voltage in the plate circuit, means for adjusting the voltage in the grid circuit, means for adjusting the current in the filament circuit, a device for simultaneously connecting said adjusting means into 80 said circuits, and means controlled by said device for compensating for the difference between the plate-filament voltages of the two tubes under abnormal conditions of adjustment of the filament circuit. 85

In testimony whereof, we have signed our names to this specification this 16th day of March, 1921.

GEORGE CRISSON.

SAMUEL P. SHACKLETON.