Dec. 7, 1948. H. H. WEICHARDT 2,455,395

ELECTRONIC CIRCUIT CONTROL AND RELAY THEREFOR

Filed Dec. 8, 1943 2 Sheets-Sheet 1

Fig. 1.

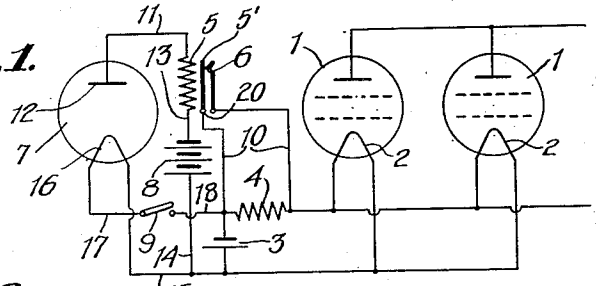


Fig. 2.

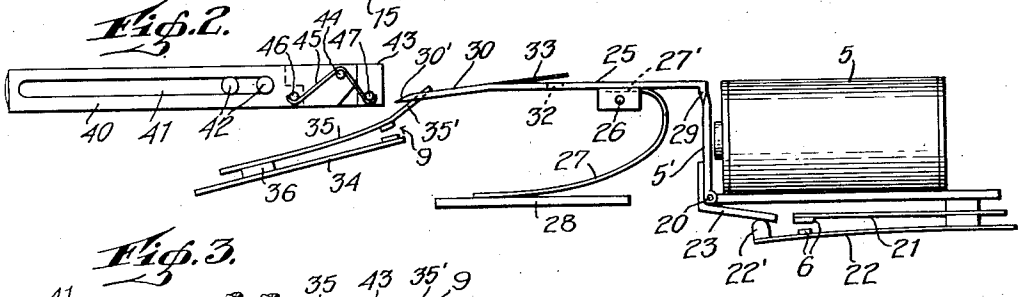


Fig. 3.

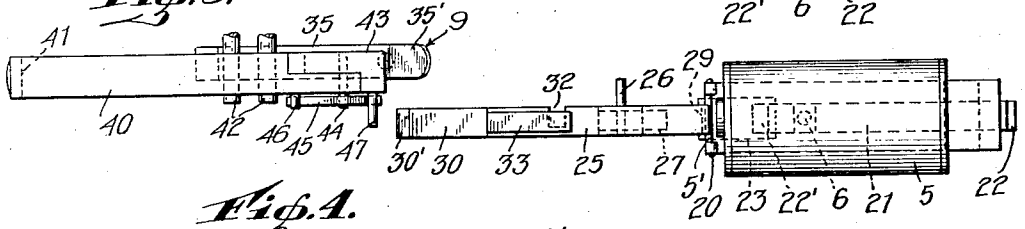


Fig. 4.

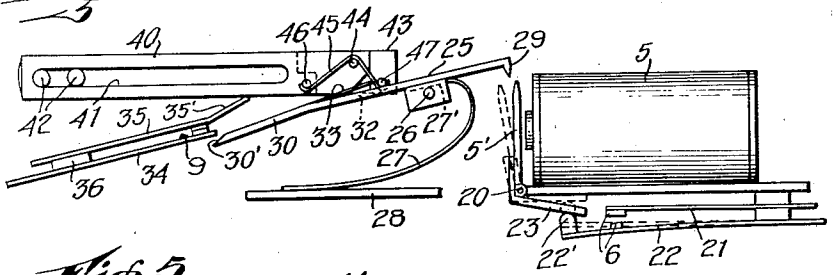
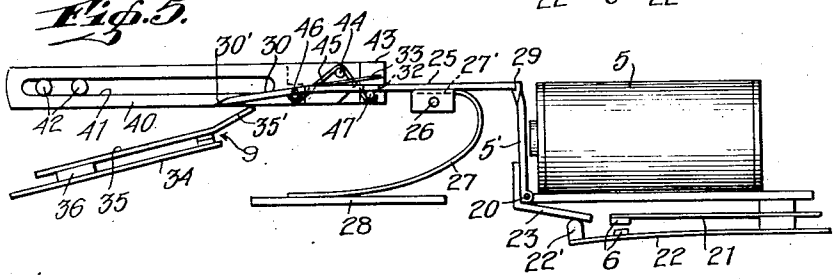


Fig. 5.



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Fig. 6.

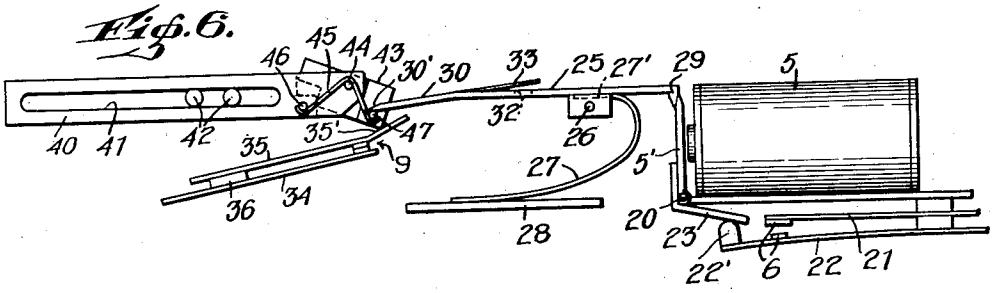


Fig. 7.

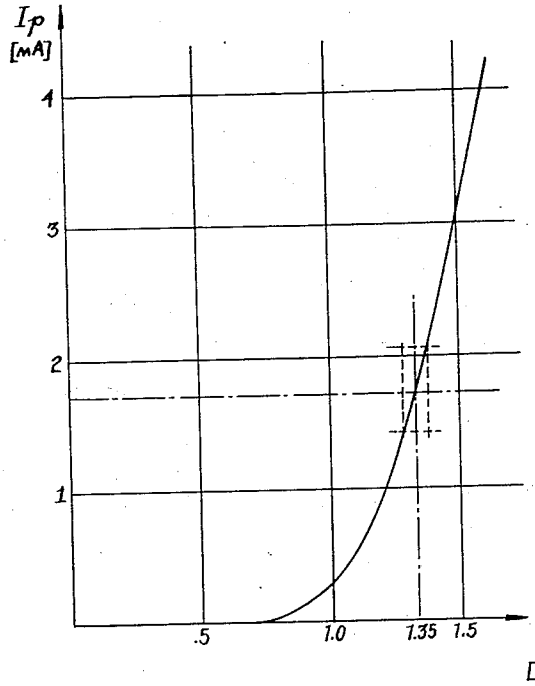
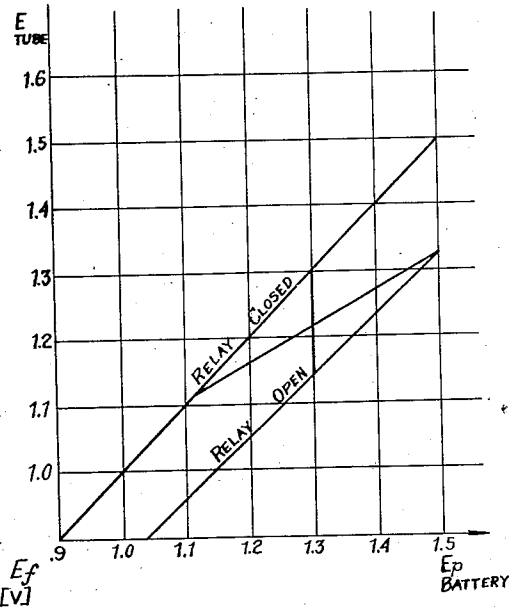


Fig. 8.



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ELECTRONIC CIRCUIT CONTROL AND RELAY THEREFOR

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15 Claims. (Cl. 315—101)

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This invention relates to relays and controls for electronic circuits, and particularly circuits embodying elctronic devices having elements energized by batteries.

In designing tubes for battery operated radio receivers, sets and the like, the difficulty arises to produce tubes which will remain within specified electrical limits in spite of changing filament supply voltage. For example, a fresh battery will usually give up to 1.6 volts but as it is used will drop down to nearly 1 volt before it is entirely exhausted and it is difficult to design tubes which will efficiently operate with this large variation in voltage supply of from 1.6 volts down to 1 volt.

One object of the invention is a radio circuit and a control therefor which will enable this differential in starting and ending voltage to be substantially reduced, as for example, by half or more. In carrying out this object of the invention the unduly large range in voltage differential can be reduced by approximately half by designing the tubes to operate at a smaller filament voltage than is customarily used, for example, at 1.2 volts instead of 1.4 volts, and by connecting in circuit with the filaments a series resistor such as will drop the voltage of a fresh battery down to approximately the required efficient operating voltage. As soon as the battery is partially exhausted or sufficiently exhausted to reduce the voltage below the value required for efficient operation of the tubes with the resistor in series, the latter is then removed from the circuit as by short-circuiting and the tube filament or filaments can now be operated directly from the battery until the battery is exhausted. Efficient and satisfactory operation of the circuit is thereby obtained notwithstanding the large variation between the voltage of the fresh battery and the voltage of the exhausted battery.

A further object of the invention is a novel and improved control for effecting the removal or short-circuiting of the resistor in series with the battery supplying the filaments of the tubes.

A further object of the invention is such a control circuit which is characterized by the simplicity with which it may be manipulated by the user of the circuit to remove the resistor connected in series with the partially exhausted battery.

A further object of the invention is such a control embodying a novel and improved relay circuit for controlling the resistor.

A further object of the invention is a novel and improved relay which is characterized by a sensitivity out of proportion to the comparatively small changes in battery voltage.

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A further object of the invention is a relay and relay circuit characterized by connection of the relay coil in the plate circuit of an electronic tube with the filament of the tube connected across the varying supply voltage whereby changes in supply voltage are multiplied in the plate circuit.

Further objects of the invention will hereinafter appear.

For a better understanding of the invention reference may be had to the accompanying drawings forming a part of this application, wherein:

Fig. 1 is a circuit, schematically illustrated, embodying the invention;

Fig. 2 to 6 inclusive are diagramatic views of a manually controlled relay circuit embodying the invention;

Fig. 7 is a graph of the Ip—Ef curve of the diode or radio tube element of the relay combination; and

Fig. 8 is a graph showing the reduction of battery voltage change through the action of the control embodying the invention.

The invention is illustrated as applied to and embodied in an electronic circuit, such as a radio receiver set comprising tubes 1, two of which are shown. The heating filaments for the tubes are indicated at 2 and these filaments are energized by the conventional battery 3. A resistor 4 is connected in series with the filament supply circuit and the set is designed to give efficient operation with the resistor 4 in circuit when the battery 3 is fresh or nearly fresh and is therefore capable of giving its maximum or approximately maximum voltage. So long as the battery 3 is not discharged or exhausted to a point where the voltage drops below a predetermined value the resistor 4 is maintained in circuit but when the exhaustion of the battery is sufficient to bring the voltage down to a predetermined value the resistor 4 is or may be removed from the circuit as by short-circuiting the same.

The means for removing the resistor 4 from the circuit comprises a relay coil 5, relay contacts 6 (Fig. 1) controlled by the coil, an electronic tube such as a diode 7, a battery 8 and a manually controlled switch 9. This battery 8 may be the B battery of the set, in which case no additional battery is needed. The relay control contacts 6 are connected by means of the wires 10 across the terminals of the resistor 4 so that when these contacts 6 are closed the resistor 4 is short-circuited and the full voltage given by the battery 3 is applied to the heating filaments 2. One side

of the relay coil 5 is connected through a conductor 11 with the anode plate 12 of the diode and the other end of the coil 5 is connected with one of the terminals of the battery 3, this connection being through a wire 13. The other side of the battery is connected through a line 14 with a line 15 leading from one side of the battery 3 to one end of the heating filament 16 of the diode. The other side of the filament 16 is connected through a wire 17 and switch 9 with a line 18 leading to one terminal of the battery 3. When the switch 9 is closed therefore the heating filament 16 of the diode is connected directly across the battery 3 and energized thereby.

In the particular embodiment shown, the switch 9 is manually operated or closed to energize the filament 16 of the diode 7. The arrangement is such that when the voltage of the battery 3 is at or above a predetermined value the plate current of the diode which flows through the relay coil 5 is strong enough to operate the contacts 6, in this embodiment strong enough to open the contacts 6. As soon however as the voltage of the battery 3 drops below this value the plate current is no longer sufficient to actuate armature 5' of the coil to control the contacts and in the particular embodiment shown thereby permitting the contacts to close and short-circuit the resistor 4. The short-circuiting of the resistor 4, as above pointed out, results in the full voltage of the battery 3 being utilized to energize the heating filaments 2.

The diode 7 cooperatively functions with and as a part of the relay to increase its sensitivity. Small changes in the voltage of the battery 3 and in the current flowing through the heating filament 16 will thus result in very substantially larger changes or variations in the flow of plate current through the relay coil 5. The graph *Ip*—*Ef* of Fig. 7 illustrates how the voltage and current changes are amplified on the relay coil 5 responsively to small changes in voltage of the battery 3. This curve of the diode 7 in the particular embodiment shown shows that with a change of filament voltage from 1.4 to 1.3 volts, namely a change of 1/10th of a volt, the plate current undergoes a change from 2.1 to 1.4 ma., a change of 30%, whereas the change in the voltage of the battery 3 is only about 7%. This amplification of the change effect upon the relay 5 renders it easy to design the relay and the switch controlled thereby so as to readily distinguish between the comparatively small changes in voltage of the battery 3 as the latter is gradually exhausted.

It is important that the regulating and control means does not consume current during the normal operation of the radio receiver set and I have illustrated in Figs. 2 to 6, somewhat schematically, a push button control mechanism cooperatively functioning with the relay 5 combination for effecting this purpose, although certain features of the invention are not limited to any particular control devices. This mechanism also enables the user to test the set at any time to determine whether the battery voltage of the battery 3 has been reduced to the predetermined value at which it is desired to short-circuit the resistor 4. Upon such check or test the control automatically determines whether the resistor 4 should be short-circuited.

Referring to the mechanism of Figs. 2 to 6, the contacts 6 are mounted on spring fingers 21 and 22 and when the armature 5' of the relay 5 is in the position to which it is actuated by the relay,

namely the vertical position as shown in the drawings, this armature through an L-member 23 fastened thereto, engages the spring arm 22 to hold the contacts 6 open, in the particular embodiment shown an abutment or lug 22' being provided on the end of the spring arm 22 which is engaged by the actuating member 23 attached to the armature 5'. The armature 5' is adapted to be locked in the vertical position, namely in the position to which it is actuated by the relay 5 by a lever member 25 pivotally mounted at 26 and urged to the horizontal position by a leaf spring 27, the latter having one end fixed to or engaging a fixed structural element 28 while the other end 27' is fastened to the lever 25. With the lever 25 thus held in the horizontal position by the spring 27 a downwardly turned part 29 on the right hand end of the lever 25 is disposed behind the free end of the armature 5' which is pivoted at 28 so as to hold the armature 5' in the actuated position even though the relay coil 5 is deenergized. The left-hand end 30 of the lever 25 is downwardly inclined and is formed with a bevel edge 30' at its end to facilitate the actuation of the lever as hereinafter described. The lever 25 is provided with a slot 32 on one side thereof intermediate the pivot point and the left hand end 30 of the lever and a leaf spring 33 is fastened at its left hand end to the top of the lever 25 and extends to the right slightly beyond the slot 32 and the right hand end of the spring 33 is elevated slightly above the surface of the lever 25.

The switch contacts 9 for connecting the filament 16 of the diode across the battery 3 are mounted on two spring arms or fingers 34 and 35 which are suitably insulated from each other as indicated at 36 and the spring finger 35 is provided with a bent end 35' for ready engagement with an actuating means in closing the contacts 9 against the tension of the spring finger 35. The means for actuating the lever 25 and the contacts 9 is a push button member 40, shown as an elongated rod, which is mounted in any suitable manner for movements toward and away from the lever 25 and the switch 9. For guiding these movements the push button or rod 40 is diagrammatically illustrated as having a slot 41 which is traversed by two or more stationary guide pins 42 when the push rod 40 is moved. The latter is provided at its right hand end with a nose piece 43 pivotally mounted thereon by a pivot pin 44. This nose piece 43 and the end of the push rod 40 are rabbeted as shown so that the nose piece forms a continuation of the outline of the rod 40. The pivotal axis or pin 44 of the nose piece 43 is disposed parallel to the pivotal axis 26 of the lever 25 and the right hand end of the nose piece 43 is locked against movements above the position shown in Fig. 2 but is free for pivotal movements in a downward direction. A leaf spring 45 passes around the pin 44 and has its ends bent about pins 46 and 47 carried respectively by the push rod 40 and the nose piece 43. Pin 47 extends outwardly far enough to engage the left hand portion 30, 30' of the lever 25 for actuating the same when the rod 40 is manipulated.

The position of the mechanism shown in Figs. 2 and 3 corresponds to the operation of the set before the voltage of the battery 3 is sufficiently reduced to require the short-circuiting of the resistor 4. The position after the short-circuiting of the resistor 4 would be the same as shown in Figs. 2 and 3 except that the armature 5' would be disposed in a position away from the vertical with its upper end on the lefthand side of the

locking part 29 of the lever 25. When the user suspects that the battery 3 is no longer sufficient to energize the filaments 2 of the tube for efficient and satisfactory operation of the set, he merely pushes the push rod 40 inwardly toward the lever 25, namely to the right as shown in the figures. This movement first releases the relay armature 5' by the pin 47 engaging the lefthand end 30 of the lever and turning the lever about the pivot 26. This permits the armature 5' of the unenergized relay coil 5 to drop counterclockwise about the pivotal axis 20, the spring arm 22 assisting in this counterclockwise movement of the armature by engaging the actuating finger 23. A continued movement of the push rod 40 results in the engagement of the upturned end 35' of the spring finger 35 and the closure of the contacts 9. The closure of the switch 9 energizes the filament 16 of the diode and if the voltage of the battery 3 is at or above a predetermined value a sufficiently strong plate current will flow through the relay coil 5 to cause the latter to actuate the armature 5' to the vertical position against the tension of the spring finger 22 and thereby reopen the contacts 6 which were temporarily closed when the lever 25 was first actuated. If the battery voltage of the battery 3 has decreased below the predetermined value, as, for example, to 1.3 volts, the plate current of the diode will not be sufficient for the relay coil 5 to actuate the armature 5' and accordingly the latter will remain in this position with the contacts 6 closed so as to short-circuit the resistor 4.

The movement of the push rod 40 to the right results in the pin 47 riding over the leaf spring 33 but as soon as the pin 47 rides over the free end of the spring 33 the spring 27 actuates the lever 25 to bring the latter into engagement with the pin 47 again. During the backward movement of the push rod 40 the pin 47 rides under the spring 33 and when it reaches the slot 32 is caused by the swinging of lever 25 under the tension of spring 27 to pass through the slot so that the further backward movement then results in the pin 47 engaging the under surface of the lever 25. Figs. 4 and 5 indicate the positions where the pin 47 is at the end of its righthand stroke, and has just passed through the slot 32, respectively. Fig. 6 shows the position where the push rod 40 is nearings its lefthand position and just before the pin 47 has passed out from under the end 30 of the lever 25.

The switch 9 which is thus closed when the push rod 40 is moved to the right is maintained closed until after the lever 25 is moved by the spring 27 to the horizontal position so as to assure the locking of the armature 5' in the position to lock the contacts 6 open, if the voltage of battery 3 is above the predetermined value.

The desired sequence of the locking or releasing of the armature 5' and of closing and opening the switch 9 may be effected in any suitable manner. In the particular embodiment shown, the pin 47 on its way to the right, depresses the lever 25, 30 and then the push rod 40 strikes the spring finger 35' of the switch 9 to close the same. The latter remains closed until the push rod returns to its original position.

The partially manual operation is desired to avoid any continuous use of power or the continuous energization of the diode and the battery 8 and to render the device sensitive when operated but positively locked or deenergized when not in operation, the filament of the diode being only energized when the push rod 40 is operated. The

only manual operation is the actuation of the push button or rod 40. The relay and cooperating mechanism function responsively to the relatively small change in voltage of the battery 3 to reopen the contacts 6 if the voltage of the battery is above the predetermined value or to permit the maintenance of the closure of the short-circuit if the voltage is below that predetermined value and this differentiating and distinguishing control are automatically effected responsive to the manual manipulation of the push rod 40. Further, the closing point of the relay is not appreciably changed by change of plate voltage of the diode as, for example, with a diode plate voltage varying from 40 to 105 volts. For example, in the embodiment exemplified by the graphs, the closing point or battery voltage above which the relay is effective to operate the armature 5' does not vary from the 1.31 volts with a variation in plate voltage of from 40 to 70 volts, and varies very little up to a plate voltage of 105, namely to 1.29. In this particular embodiment the short-circuiting point for the resistor R was a voltage of 1.31 at a plate voltage of 45 volts (graph, Fig. 7). A voltage change from 1.1 to 1.5 volts in the battery is reduced by the relay and control set forth to a change from 1.1 to 1.31 volts of filament voltage. The regulation acts on changes of voltage and is independent of the number of tubes used in a particular set. Only the size of the resistor 4 has to be adjusted to the total filament current of the set.

In the particular embodiment shown, the current supply to the filaments 2 is regulated by a battery supply and a controllable resistance in series but it is understood that certain features of the invention are applicable to other types of controls.

I claim:

1. Means for testing a battery in circuit with one or more vacuum tube filaments and modifying said circuit in accordance therewith, comprising, a resistor in circuit with said battery when the battery is at full voltage, and relay control means responsive to the voltage of said battery for short-circuiting said resistor when the voltage of the battery drops to a predetermined lower value through the use thereof in heating the aforementioned filaments.

2. In a control means for a resistance connected in series with a battery supplying energy to the heating filament of an electronic tube, the combination of electromagnetic means controlling said resistance and responsive to the battery voltage when energized to maintain the resistance in circuit during the first part of the life of the battery and until the battery voltage drops through discharge to a predetermined value and to cut out said resistance when the battery voltage drops through discharge to said predetermined value, with means momentarily energizing said electromagnetic means including a manually operated device for testing the voltage of the battery during the life of the latter.

3. In a battery operated vacuum tube filament circuit, means for testing the battery and causing the circuit to be modified if the battery voltage has fallen to a predetermined level, comprising a resistor in circuit with said battery, and relay control means responsive to the voltage of said battery for short-circuiting said resistor when the voltage of the battery drops to a predetermined value, said relay control means comprising a switch for short-circuiting said resistor, a relay coil and armature for controlling said switch, a

diode tube whose energizing filament is adapted to be connected across the battery, a source of direct current supply connected across the diode filament and the plate of the diode and the relay coil being connected between the plate and the battery.

4. In a battery operated vacuum tube filament circuit, means for testing the battery and causing the circuit to be modified if the battery voltage has fallen to a predetermined level, comprising a resistor in circuit with said battery, and relay control means responsive to the voltage of said battery for controlling said resistor when the voltage of the battery drops to a predetermined value, said relay control means comprising a switch for short-circuiting said resistor, a relay coil and armature for controlling said switch, a diode tube whose energizing filament is adapted to be connected across the battery, a source of direct current supply connected across the diode filament and the plate of the diode and the relay coil being connected between the plate and the battery, and manual means for connecting and disconnecting the filament of the diode across said battery.

5. In an electronic circuit, one or more tubes having heating filaments therein, a battery source of supply for energizing said filaments, a resistor in circuit with said battery, and relay control means responsive to the voltage of said battery for controlling said resistor when the voltage of the battery drops to a predetermined value, said relay control means comprising a switch biased to closing position for short-circuiting said resistor, a relay coil for actuating said switch against the bias thereof to open the same, an electronic tube having one element adapted to be energized by the battery and its plate connected in circuit with a relay coil to cause the plate current to flow through the coil, and means for controlling the circuit of said element.

6. A battery operated vacuum tube heater circuit adapted to be modified when the battery voltage falls to a predetermined value to substantially restore the tubes to normal operating efficiency, a resistor connected in circuit between the battery and the heaters and control means for said resistor comprising a relay coil responsive to the voltage of said battery together with diode vacuum tube means for amplifying the effect of voltage changes of the battery upon the relay for short-circuiting said resistor if the voltage of the battery is below a predetermined value and manually operable means for periodically energizing the relay coil.

7. In an electronic circuit having one or more radio tubes having heating filaments therein and a battery supply for energizing said filaments, relay means for controlling the voltage supplied by said battery to the filaments comprising a resistor in the battery circuit, a relay coil and an electronic tube having a filament adapted to be energized by said battery and its plate connected in series with the relay coil, and manual means controlling the circuit of the last said filament.

8. In a vacuum tube circuit having one or more vacuum tubes and a battery source of supply for energizing the filaments of said tubes, means for modifying the voltage supplied by said battery to the filaments comprising a resistor in the battery circuit, a relay coil, an armature biased in a direction opposite to the pull of the coil, means for locking said armature in one position against the bias, a manual device for releasing said locking means and at the same time energizing the relay responsively to the battery voltage.

9. In a vacuum tube circuit having one or more vacuum tubes and a battery source of supply for energizing the filaments of said tubes, means for modifying the voltage supplied by said battery to the filaments comprising a resistor in the battery circuit, a relay coil, an armature, control contacts biased to closed position and biasing said armature against the pull of the relay coil, a pivoted lever having means on one end for locking the armature in position to hold the contacts open and a reciprocable member having a pin engaging one surface of one end of said lever to release the lock in one direction of movement and energizing the coil and in its opposite direction of movement said pin disengaging said surface thereof to permit the lever to resume its locking position.

10. In a vacuum tube circuit having one or more vacuum tubes and a battery source of supply for energizing the filaments of said tubes, means for modifying the voltage supplied by said battery to the filaments comprising a resistor in the battery circuit, a relay coil, an armature, control contacts biased to closed position and biasing said armature against the pull of the relay coil, a pivoted lever having means on one end for locking the armature in position to hold the contacts open and a reciprocable member having a pin engaging one surface of one end of said lever to release the lock in one direction of movement and energizing the coil and in its opposite direction of movement said pin passing through a slot in said lever to permit the lever to resume its locking position, said reciprocable member having a pivoted end which carries said pin and said lever having a guard member for forcing the pin through the slot in one direction of movement.

11. In an electronic circuit, having electronic tubes and a battery for energizing the filaments of said tubes, a resistor between the battery and the filaments, and means for short-circuiting said resistor when the voltage of the battery drops to a predetermined value, comprising an electromagnet responsive to the voltage of the battery, a switch for short-circuiting said resistor, an armature operated by said electromagnet to hold said switch open, means for locking the armature in a position to hold said switch open, a circuit for energizing said electromagnet, and a manual device for releasing said armature to permit closure of said switch and said last named circuit.

12. The combination of a battery operated radio set with a user battery voltage testing and resistor cut-out device to modify the heater circuit if the filament battery voltage is below a predetermined level, comprising a resistor in the heater circuit, switch means for short-circuiting the resistor, a solenoid responsive to the voltage of the battery for closing said switch means when the battery voltage drops to a predetermined value, means for locking said switch means in open position, a circuit for energizing said solenoid including a battery and a tube having a heated cathode responsive to the battery voltage and an anode plate and a manual device for releasing the locking means to permit closing of the switch means if the voltage of the battery is too low and for connecting the heated cathode across the battery of the radio set.

13. In a control and testing means for the battery voltage supplied to a heating filament of a radio tube, the combination of a switch means for short-circuiting a resistance in the heater circuit when the voltage of the battery drops to a

predetermined value, said switch means being biased to resistance short-circuiting position, an electromagnet having an armature tending to hold said switch means open when the magnet is energized but responsive to a predetermined drop in voltage of the battery to release the switch means and to permit the closure thereof, means for locking said switch means in open position, a circuit for energizing said electromagnet including a source of direct current and a tube having a heated cathode and an anode plate, said cathode being heated by said battery, and manually operated means which upon movement in one direction first releases the switch locking means and then connects the heated cathode across said battery and when moved in the opposite direction first releases said locking means and then opens the circuit of the electromagnet.

14. A circuit for detecting changes in voltage of a battery used to energize battery type vacuum tubes comprising a diode vacuum tube, a circuit connecting the filament of the diode across the terminals of the battery to be tested, a plate circuit for the diode including a plate battery and means in the plate circuit responsive to changes in current therein to indicate a change in the filament battery voltage.

15. Means under manual control for testing the battery of a battery operated circuit while under load and modifying said circuit if the battery voltage is below a predetermined level when the manual control is operated, comprising a resistor in said circuit, a relay having contacts connected with said resistor, and manual means for placing said relay in condition to respond to the battery voltage, whereupon said contacts will close if the battery voltage is below a predetermined value.

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