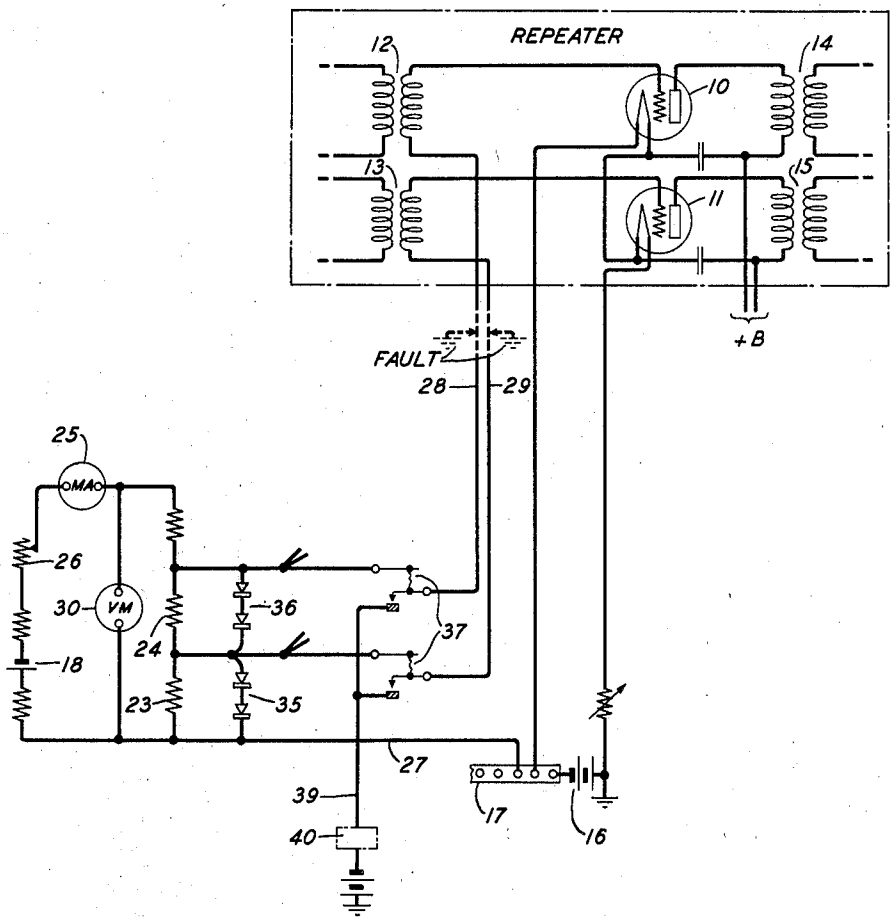
April 11, 1939. A. F. GRENELL 2,154,239

VOLTAGE REGULATING CIRCUIT

Filed Nov. 13, 1936



INVENTOR
A.F. GRENELL
BY H. A. Burgess
ATTORNEY

Patented Apr. 11, 1939 2,154,239

UNITED STATES PATENT OFFICE

2,154,239

VOLTAGE REGULATING CIRCUIT

Arthur F. Grenell, Montclair, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application November 13, 1936, Serial No. 110,607

3 Claims. (Cl. 179—171)

This invention relates to a voltage regulating circuit and more particularly to a grid-biasing arrangement for a thermionic repeater operated from a common grid-supply circuit.

In the protective system for thermionic repeaters disclosed in the copending application of Edward Vroom, Serial No. 110,615, filed November 13, 1936, now Patent No. 2,115,152, and assigned to the same assignee to which this application is assigned, copper-oxide rectifiers are bridged across the resistors utilized to produce the grid-biasing potentials. In the operation of this system it was found that the grid-biasing potentials varied slightly due to the instability of the rectifiers.

It is an object of this invention to produce substantially constant grid-biasing potentials for a thermionic repeater by compensating for the influence of temperature on the performance of the copper-oxide rectifiers included in the common grid-supply circuit.

In the preferred form of the invention each grid-biasing resistor is provided with a predetermined positive coefficient of resistance to compensate for the resistance variations of the copper-oxide rectifier bridged thereacross. Accordingly, increments and decrements of temperature relative to a certain operating level will simultaneously affect the resistances of the rectifiers and the grid-biasing resistors such that decreases in the rectifiers will be off-set by increases in the grid-biasing resistors and vice versa. Thus, the variations of the grid-biasing resistors compensating for the instability of the rectifiers enable the maintenance of substantially constant grid-biasing potentials.

The invention will be more readily understood from the following description taken together with the accompanying drawing which illustrates its preferred form.

The drawing is a portion of the system for energizing and testing thermionic repeaters disclosed in the patent of E. Vroom, No. 1,616,156, issued February 1, 1927, and the protective system therefor described and claimed in the copending application of E. Vroom, supra.

Referring to the drawing, a thermionic repeater is represented as comprising electron discharge devices 10 and 11, each of which includes a control grid and a cathode, input transformers 12 and 13, and output transformers 14 and 15. Cathode heating current is supplied from a common 24-volt battery 16 which has its negative terminal connected to a negative bus-bar 17 and its positive terminal to ground.

Grid-biasing potential is obtained from a common grid-supply circuit comprising 10-volt battery 18, grid-biasing resistors 23 and 24, milliammeter 25, and rheostat 26. A link 27 joins the positive terminal of impedance 23 and the negative bus-bar 17. Potentials produced across the grid-biasing resistors 23 and 24 are supplied over leads 28 and 29, respectively, to the control grids of the respective electron discharge devices. Normally, no current flows over these leads.

Milliammeter 25 serves to indicate the magnitude of current flowing in the common grid-supply circuit. It is understood that this current is to be maintained at a level that will produce substantially constant potentials across the grid-biasing resistors 23 and 24. Voltmeter relay 30 is operatively associated with the milliammeter 25 to provide an alarm whenever the potentials produced across the grid-biasing resistors 23 and 24 vary from a predetermined level. A more detailed description of the repeater circuit including the regulatory apparatus therefor may be had by referring to the patent of E. Vroom, supra.

The repeater also includes a safety and alarm system which comprises copper-oxide rectifiers 35 and 36, or similar asymmetrical conductors, bridged across the grid-biasing resistors 23 and 24, respectively, and current responsive devices 37, 37 disposed in the grid leads 28 and 29. As may be seen in the drawing, the rectifiers are poled against the current flow from the grid battery. The current responsive devices are preferably of the fuse-link type disclosed in the patent of M. C. Rorty et al., No. 761,916, issued June 7, 1904, and, when operated in response to current flowing in the grid leads, interrupt the latter and connect them through lead 39 to a suitable alarm 40.

The safety system is so designed that an accidental ground occurring on either of the grid leads draws current from the cathode battery. This current actuates the respective current responsive device to disconnect the defective lead from the common grid-supply circuit, and simultaneously therewith effects the operation of alarm 40. A more detailed description of the protective circuit is disclosed in the copending application of E. Vroom, supra.

The present invention is applied to the thermionic repeater including the protective system therefor described above. In the operation of this repeater, it was found that the performance of the copper-oxide rectifiers was influenced by changes of temperature. That is, increments and decrements of temperature relative to the normal operating level caused decreases and increases, respectively, in the resistances of the rectifiers. It is understood that at the normal operating temperature a certain amount of current from the grid battery passes through the rectifiers in the reverse direction although as previously indicated, the rectifiers are poled against the flow of this current.

As the resistances of the rectifiers vary in the reverse direction due to the influence of tem-

perature, current from the grid battery is shunted therethrough in changing amounts. The amounts of shunt current depend upon the relative values of the resistances of the rectifiers in the reverse direction and the grid-biasing resistors **23** and **24**. Referring to the drawing, it is seen that the rectifiers and the two grid-biasing resistors **23** and **24** form a parallel branch in the common grid-supply circuit. As a result of this instability of the rectifiers, the current supplied by the grid battery to the grid-biasing resistors **23** and **24** is caused to undergo variations. This means that the biasing potentials impressed on the grids of the respective electron discharge devices are also varied. Obviously, varying biasing potentials will impair the efficiency of the repeater.

In addition, this instability of the rectifiers occasions frequent operations of the regulatory apparatus which includes the milliammeter **25** and the voltmeter relay **30**. Thus, an attendant is required to spend considerable time in checking the current flowing in the common grid-supply circuit.

This invention, therefore, compensates for the influence of temperature on the performance of the copper-oxide rectifiers by fixing each grid-biasing resistor at a definite amount for the normal operating temperature and, in addition, by providing each with a predetermined positive coefficient of resistance per degree change in temperature relative thereto. In the aforedescribed repeater, the grid-biasing resistors **23** and **24** are fixed at 329 and 405 ohms, respectively, for a normal operating temperature of 20° centigrade and, also, are provided with a positive coefficient of 0.00155 to 0.00160 per degree change relative thereto. At the normal operating temperature, the resistances of the copper-oxide rectifiers in the reverse direction are relatively large, hence very little current from the grid battery will flow in this direction.

The temperature coefficient may be provided as follows: (1) by making the resistors **23** and **24** from a suitable alloy having the required coefficient of resistance such, for example, as brass; and (2) by forming the resistors **23** and **24** in two sections, one of which is copper and the other a material having a relatively high coefficient of resistance, the copper and other material being proportioned to provide the proper temperature coefficient of resistance.

It is understood that the positive coefficient for the grid-biasing resistors **23** and **24** is to be provided in view of the number and dimension of the elements comprising each copper-oxide bridge and, further, that in the determination of the above-indicated coefficient each grid-biasing resistor is shunted by six rectox discs.

Accordingly, increments and decrements of temperature relative to 20° centigrade will simultaneously influence the resistances of the rectifiers and the grid-biasing resistors **23** and **24** so that as the rectifiers decrease, the grid-biasing resistors **23** and **24** increase, and vice versa. In this way the variations in the grid-biasing resistors **23** and **24** compensate for the instability of the rectifiers thereby enabling the maintenance of substantially constant grid-biasing potentials. This is readily evidenced by an application of Ohm's law.

It is also apparent that this automatic control of the grid-biasing resistors **23** and **24** obviates the need of performing many operations with the regulatory apparatus and, as a direct result releases more time of the attendant to other duties.

What is claimed is:

1. In combination, an electron discharge device including a control grid and a cathode, a grid-biasing circuit comprising a source of current and a resistance, the latter being provided with a positive temperature coefficient of resistance and developing a predetermined potential thereacross, a source of current for energizing the cathode, a lead connecting the resistance and the control grid, an asymmetrical conductor bridging the resistance and poled against the flow of grid current for connecting the grid lead and the cathode source of current, and a current-responsive means for interrupting the grid leads in response to current flowing therein, the temperature coefficient being so proportioned as to compensate for variations in the resistance of the asymmetrical conductor in the reverse direction whereby the predetermined potential developed across the resistance of the grid-biasing circuit is constantly maintained.

2. In combination, in a repeater circuit comprising a pair of electron discharge devices each of which includes a control grid and a cathode, a common grid-supply circuit embodying a source of current and at least two resistances each of which is provided with a positive temperature coefficient of resistance and develops a predetermined potential thereacross, a common source of current for energizing the cathodes, leads connecting the resistances and the control grids, an asymmetrical conductor bridging each of the resistances, the asymmetrical conductors being poled against the flow of current in the common grid-supply circuit and joining the control-grid leads and the cathode source of current, and current-responsive means for interrupting the control-grid leads in response to a current flow therein, the temperature coefficient being so proportioned as to compensate for variations in the resistances of the asymmetrical conductors in the reverse direction whereby the predetermined potentials developed across the resistances of the common grid-supply circuit are constantly maintained.

3. In an electrical circuit subject to temperature variations, the combination comprising electrical apparatus, one energizing means connected to the apparatus and including a source of current and a resistance, other energizing means connected to the apparatus, means responsive to energy from the other energizing means for controlling connections between the apparatus and the one energizing means, and means connecting the energy responsive means and the other energizing means and including a unidirectional device bridging the resistance to oppose current from the one energizing means, the resistance having a positive temperature coefficient proportioned to compensate for variations in the resistance of the unidirectional element in the reverse direction to maintain the effective resistance of the resistance and bridging unidirectional device substantially constant.

ARTHUR F. GRENELL.