July 14, 1942.

C. S. YEUTTER

2,289,951

ELECTRON APPARATUS

Filed July 9, 1941

FIG. 1

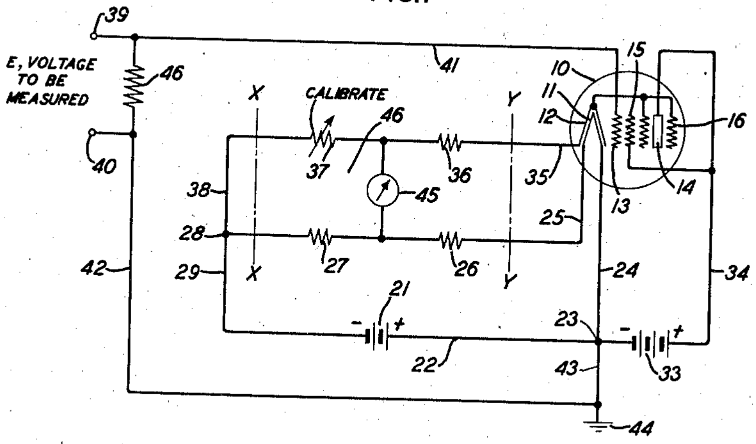


FIG. 2

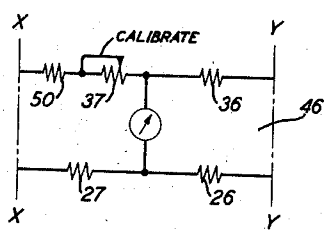
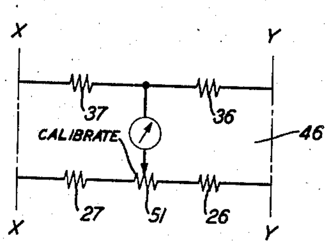


FIG. 3



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ELECTRON APPARATUS

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Application July 9, 1941, Serial No. 401,560

4 Claims. (Cl. 171—95)

This invention relates to a hot cathode electron apparatus and, more particularly, to an arrangement to compensate for variations in magnitude of the heater energizing voltage in such apparatus.

Heretofore, in the operation of a hot cathode electron apparatus in a measuring circuit, it has been found that variations in the magnitude of the voltage energizing the heater caused different changes in the resistance of both the anode-cathode and heater circuits. Such resistance changes effect undesirable variations in the current of the anode-cathode circuit, and, accordingly, introduce errors in the meter readings occasioned by this current.

The main object of the invention is to obtain accurate readings in a measuring device embodying hot cathode electron apparatus.

Another object is to compensate for variations of the voltage energizing the heater of hot cathode electron apparatus.

A further object is to control the effective anode-cathode current of hot cathode electron apparatus.

In a specific embodiment, the present invention comprises an electron device embodying a hot cathode, a heater, a control grid, and an anode, and connected such that the anode-cathode circuit includes a source of direct potential to energize the anode, and the heater circuit provides a source of direct potential to energize the heater. A resistance bridge network embodying an indicator across one diagonal and connecting effectively the other diagonal in the anode-cathode and heater circuits serves to produce an initial zero reading on the indicator at no voltage input to the control grid-cathode circuit. The ratio arms connected in the respective anode-cathode and heater circuits are provided with such amounts of resistance that the resistance ratio therebetween is maintained substantially constant regardless of variations in the magnitude of the heater energizing voltage. This tends to control the amount of current flowing in the anode-cathode circuit to compensate for variations in the magnitude of the heater energizing voltage. This hot cathode electron device is arranged to measure progressively increasing amounts of negative voltage.

The invention will be readily understood from the following detailed description taken together with the accompanying drawing, in which:

Fig. 1 is a schematic circuit illustrating a specific embodiment of the invention; and

Figs. 2 and 3 show modifications of Fig. 1.

The same reference numerals are employed to identify the same elements appearing in the several figures of the drawing.

Referring to Fig. 1, a thermionic electron device 10 comprises a heater 11, a cathode 12, control grid 13, anode 14, screen electrode 15 and suppressor grid 16.

The heater 11 is energized in a circuit embodying in series positive terminal of source 21 of direct potential, lead 22, common terminal 23, lead 24, heater 11, lead 25, fixed resistors 26 and 27 in series, common terminal 28, lead 29 and the negative terminal of the source 21.

The anode 14 is energized in a circuit extending in series from the positive terminal of source 33 of direct potential, lead 34, anode 14 and cathode 12, lead 35, fixed resistor 36 and adjustable resistor 37 in series, lead 38, common terminal 28, lead 29, source 21, lead 22, common terminal 23, and back to the negative terminal of the source 33.

A progressively increasing negative voltage E to be measured is applied across the input terminals 39 and 40, of which the terminal 39 is connected by lead 41 to the control grid 13, and the terminal 40 is connected by lead 42 to a link 43 extending from the common terminal 23 and terminating in ground 44. A resistor 46 is connected across the input terminals 39 and 40. Across the mid-points of the series resistors 26 and 27 and 36 and 37 is disposed an indicator 45. The control grid 13 is supplied with a suitable negative biasing voltage effective over a circuit extending from the negative terminal of the source 33, common terminal 23, link 43, lead 42, resistor 46, lead 41 to the control grid 13.

The resistors 26, 27, 36 and 37 constitute a bridge network 46 in which a horizontal diagonal comprising the common terminal 28 and corresponding opposite ends of resistors 26 and 36 is effectively connected in both the previously described heater and anode energizing circuits, and a vertical diagonal embodies the indicator 45.

In the operation of Fig. 1, the adjustable resistor 37 is actuated until the indicator 45 shows an initial zero reading. This means that when the heater 11 is energized with a constant magnitude of voltage from the source 21, the anode-cathode current flowing in the resistor 36 divides such that a portion flows in the indicator 45 and resistor 27 to the common terminal 28 while another portion flows in the adjustable resistor 37 and lead 38 to the common terminal 28. Hence, for this zero reading, the bridge arms embodying the resistors 26 and 36 have a certain ratio.

Assuming an increase in the magnitude of the voltage of the heater energizing source 21, the following action takes place simultaneously: (1) the effective negative biasing voltage on the control grid 13 is reduced as the increased positive voltage tends to decrease the effect of negative biasing voltage of the source 33 in the biasing circuit hereinbefore described; (2) the heater 11 causes the cathode 12 to increase the emission of electrons thereby lowering the resistance of the anode-cathode circuit; and (3) due to the non-linear current-voltage characteristic of the heater 11, the resistance of the latter decreases with an increase in the magnitude of the energizing voltage therefor near the operating point of the heater 11.

Assuming a decrease in the magnitude of the voltage of the heater energizing source 21, the following action takes place simultaneously: (1) the effective negative biasing voltage on the control grid 13 is increased as the decreased positive voltage tends to increase the effect of the negative biasing voltage of the source 33 in the biasing circuit traced previously; (2) the heater 11 causes the cathode 12 to decrease the emission of electrons thereby increasing the resistance of the anode-cathode circuit; and (3) due to the non-linear current-voltage characteristic of the heater 11, the resistance of the latter increases with a decrease in the magnitude of the energizing voltage therefor near the operating point of the heater 11.

The increase or decrease in the magnitude of the heater energizing voltage of the source 21 changes the ratio of bridge arms embodying the resistors 26 and 36 such that variations are introduced in the reading of the indicator 45. Hence, the measurement of the input voltage E will tend to be erroneous.

To overcome such tendency, the resistance of the previously described anode-cathode and heater energizing circuits is built out by increasing the amounts of the respective linear resistances 36 and 26 such that a substantially constant ratio exists between the bridge arms embodying the latter two resistances for variations of the magnitude of the voltage of the source 21. Consequently, variations of the magnitude of the voltage of the heater energizing source 21 will have substantially no effect on the readings of the indicator 45.

In the operation of Fig. 1, the calibrated resistor 37 is initially actuated to produce a zero reading on the indicator 45 when no voltage is applied across the terminals 39 and 40 as hereinbefore explained. So the negative voltage E of progressively increasing magnitude is impressed on the latter terminals, the effective biasing voltage on the control grid 13 is correspondingly reduced to cause an increase in the flow of current in the anode-cathode circuit. This increase is recorded on the indicator 45. In other words, the substantially constant ratio between the bridge arms 26 and 36 serves to render the indicator responsive only to variations in the voltage E impressed on the terminals 39 and 40.

Figs. 2 and 3 illustrate other modifications of the bridge network 46. In this connection it is to be understood that the circuit portions included between the lines X—X and Y—Y in either of Figs. 2 and 3 may be substituted for the circuit portion included between the corresponding lines X—X and Y—Y of Fig. 1. It is noted that Fig. 2 is substantially identical with Fig. 1 in that the entire resistance of the anode-cathode circuit is varied, while in Fig. 3 the entire resistance of the heater circuit is varied.

In a specific embodiment of Fig. 2, the elements of the bridge network 46 comprised the following resistance values:

Resistance 26=17 ohms
Resistance 27=15 ohms
Resistance 36=45,000 ohms
Resistance 37=4,000 ohms
Resistance 50=8,000 ohms

In a specific embodiment of Fig. 3, the elements of the bridge network 46 comprised the following resistance values:

Resistance 26=12.7 ohms
Resistance 27=14 ohms
Resistance 36=45,000 ohms
Resistance 37=10,200 ohms
Resistance 51=5 ohms

What is claimed is:

1. In combination, in an electron discharge system, an electron device including a cathode, a cathode heater and an anode, circuit means to connect said anode and cathode, a source of direct potential in said anode-cathode circuit means, other circuit means connected across said heater, a source of direct potential in said other circuit means, and means to maintain substantially constant the ratio of the resistance of said anode-cathode circuit means to the resistance of said other circuit means for variations in the magnitude of the voltage of said heater source, comprising a bridge network having one diagonal effectively connected in both said anode-cathode circuit means and said other circuit means, and an indicator applied across the other diagonal of said network.

2. In combination, in an electron discharge system, an electron device comprising a cathode, a cathode heater and an anode, circuit means to connect said anode and cathode, a source of direct potential in said first-mentioned circuit means to energize said anode, further circuit means connected across said heater, a source of direct potential in said further circuit means to energize said heater, and a resistance bridge network connecting both said anode-cathode and heater circuit means such that a first pair of arms is effectively in said anode-cathode circuit means, a second pair of arms is effectively in said further circuit means, and a terminal connecting corresponding ends of both said first and second pairs of arms is common to both said anode-cathode and heater circuit means, the resistance of corresponding individual arms of said first and second pairs of arms proportioned to maintain a substantially constant ratio for variations in the magnitude of the voltage of said heater energizing source, and an indicator applied across the mid-points of both said first and second pairs of arms.

3. In combination, in an electron discharge system, an electron device comprising a cathode, a cathode heater, and an anode, circuit means to connect said anode and cathode, a source of direct potential in said first-mentioned circuit means to energize said anode, further circuit means applied across said heater, a source of direct potential in said further circuit means to energize said heater, a resistance bridge network connecting both said anode-cathode and heater circuit means such that a first pair of arms, one

of which is adjustable, is connected effectively in said first-mentioned circuit means in series with said anode-cathode energizing source, a second pair of arms is effectively connected in said further circuit means in series with said heater energizing source, and a terminal is common to both said first and second pairs of arms, corresponding individual arms of said first and second pairs of arms proportioned to maintain a substantially constant ratio for variations in the magnitude of the voltage of said heater energizing source, and an indicator applied across mid-points of said first and second pairs of arms.

4. In combination, in an electron discharge system, an electron device comprising a cathode, a cathode heater, and an anode, circuit means to connect said anode and cathode, a source of direct potential in said anode-cathode circuit means, further circuit means applied across said cathode heater, a source of direct potential in said further circuit means, a bridge network connecting both said anode-cathode and heater circuit means such that a first pair of arms each embodying an individual resistor is connected effectively in said anode-cathode circuit means in series with said anode-cathode energizing source, a second pair of arms each embodying an individual resistor is effectively connected in said further circuit means in series with said heater energizing source, a resistor is interposed in series intermediate said second pair of arms, and a terminal is common to both said first and second pairs of arms, corresponding individual resistors of both said first and second pairs of arms proportioned to maintain a substantially constant ratio for variations in the magnitude of the voltage of said source in said further circuit means, and an indicator having one terminal connected to the mid-point of said first pair of arms and another terminal connected adjustably to said last-mentioned resistors.

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