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THERMAL INERTIA LAMP CATHODE TESTING

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Fig. 1.

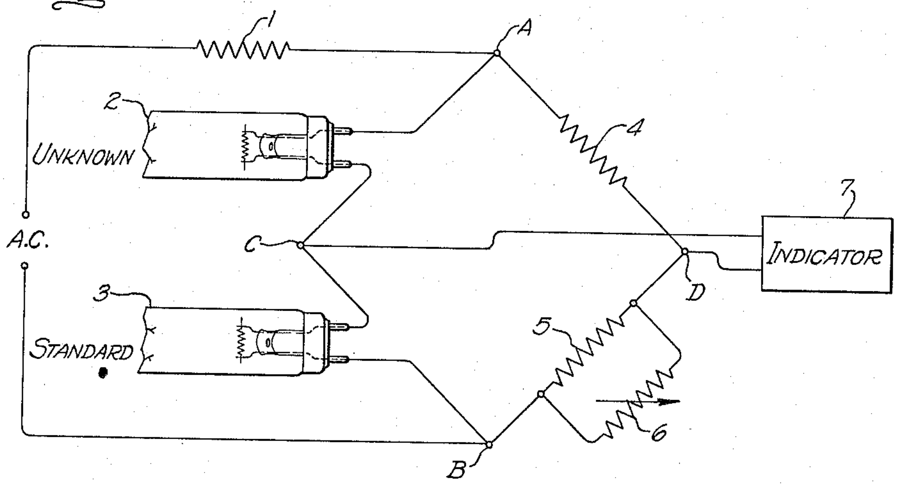
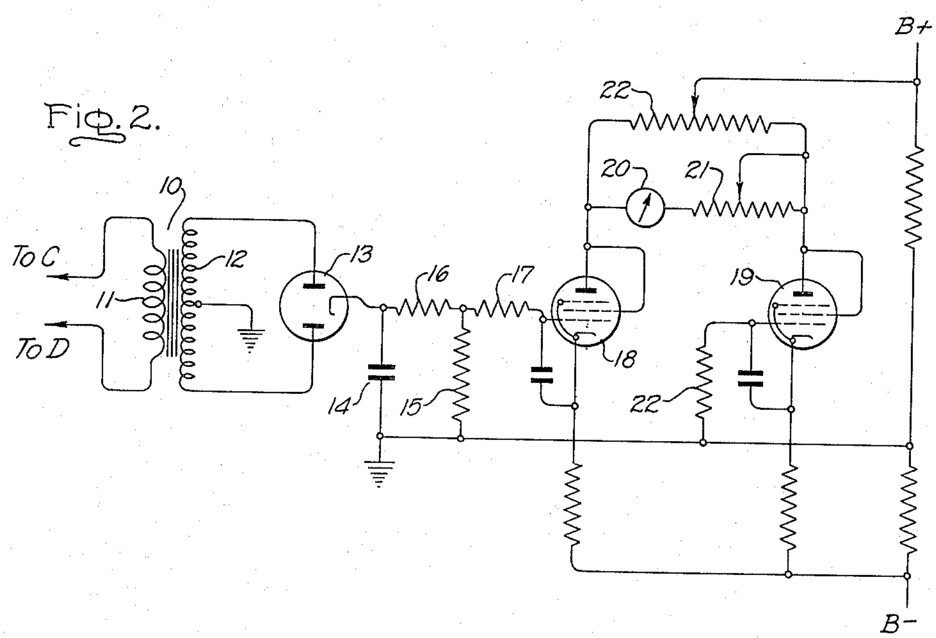



Fig. 2.

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## THERMAL INERTIA LAMP CATHODE TESTING

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8 Claims. (Cl. 324—20)



This invention relates generally to the manufacturing of electric discharge lamps having cathodes of the activated type, and more particularly to a method of measuring the quantity of emission mixture deposited on the cathode.

It is well known, of course, that the performance and life of electric discharge devices, in particular, discharge lamps of the fluoroescent type, are very much influenced by the amount of activated emission mix deposited on the cathodes. The cathodes are generally constructed of tungsten wire formed into a coil of suitable dimensions and are mounted on stem presses at opposite ends of the lamps. The tungsten itself does not have sufficient electron emission to carry effectively the arc discharge current of the lamp during operation. Accordingly, the cathodes are provided with some activating substance which emits electrons more readily than the tungsten itself. Such an activating substance may be a mixture of barium and strontium oxides. When heated, barium or strontium oxides emit electrons copiously and support the arc discharge current without sputtering and with only a small heat loss.

It is essential to the successful manufacture of lamps that the amount of emission mixture on the filamentary cathodes be accurately controlled in order to assure uniform quality in the lamps. In the past, the amount of emission mixture on the cathodes of a lamp was generally determined by fracturing the lamp, removing the cathode, weighing it and subsequently dissolving out the emission mixture by means of acids and again weighing the cathode. The difference between the two weights gave the amount of emission mixture dissolved by the acid and, accordingly, the desired figure. It need hardly be said that such a method of weighing or measuring the amount of emission mixture on a cathode is wasteful since the lamp is destroyed in the process. At best it can only serve as a check for sampling lamps out of a production batch.

Accordingly, it is an object of my invention to provide a new and improved nondestructive method of measuring the amount of emission mixture on a filamentary cathode for discharge device.

A further object of my invention is to provide an improved method, suitable for production line usage, of measuring the amount of emission mixture on the filamentary cathodes of an electric discharge device which method does not cause any deterioration or modification of the operating characteristics of the device.



A further object of my invention is to provide apparatus for readily carrying out my method of testing.

My improved testing method utilizes basically a Wheatstone bridge circuit in a manner to compare the rate of heating of a cathode coated with a quantity of the emission mixture which is to be determined with the rate of heating of an uncoated cathode. The method is applicable to any type of electrode wherein the conductive element or coil has an appreciable temperature coefficient of resistance. For instance, the usual tungsten filament cathodes of fluoroescent lamps have a high positive temperature coefficient of resistance. However, the same method could be applied to electrode elements having a lesser positive coefficient, or even having a negative coefficient, just so long as the coefficient is not zero. The difference in temperature which develops during the course of heating momentarily causes a difference in the electrical resistances of the two cathodes which, in turn, causes an unbalance in the bridge. This unbalance may be measured through a suitable indicating device and, by comparison with suitable calibration charts, gives an indication of the amount of emission mixture on the coated cathode.

For further objects and advantages and for a better understanding of the invention, attention is now directed to the following description and accompanying drawings. The features of the invention believed to be novel will be more particularly pointed out in the appended claims.

In the drawings:

Fig. 1 is a schematic diagram showing the essential elements of a Wheatstone bridge circuit for carrying out the method of my invention.

Fig. 2 is a schematic diagram of an improved detecting or indicating system incorporating a vacuum tube voltmeter which may be utilized as an indicator with the bridge circuit of Fig. 1.

In carrying out the method of my invention, a Wheatstone bridge of the usual type may be utilized such as is illustrated in Fig. 1. The two pairs of conjugate points of the bridge are denoted by A—B, and C—D. A source of voltage, for instance, a commercial supply at 110 volts, 60 cycles, is connected in series with a current limiting resistor 1 across injut conjugate points A—B. The electrode terminals of the lamp wherein the amount of emission mixture deposited upon the electrode is to be determined are connected as the unknown impedance between points A—C. A similar lamp of standard construction but wherein the usual emission mixture deposit upon the electrode has been omitted is connected as the standard impedance between terminals B—C. The usual ratio arm resistances 4 and 5 are connected between terminals A—D and B—D, respectively, an additional adjustable resistance 6 being connected in parallel with resistance 5 in order to facilitate securing a fine balance of the bridge. A suitable indicator or voltage measuring device 7 is connected between the output conjugate points or terminals C—D.

In carrying out the preferred form of my method of determining the amount of emission mix on a lamp cathode, the terminals of the unknown coated lamp and the terminals of a standard uncoated lamp are connected as shown in the circuit of Fig. 1. An alternating voltage is applied to the bridge sufficient to cause a current to flow through the lamp electrodes of a value approximately equal to that utilized by the lamp in normal operation. After 60 seconds, or slightly less, when both lamps have reached equilibrium temperature, the bridge is balanced by adjustment of resistance 6 so that the deflection in the indicator 7 is reduced to zero. Then the voltage source is disconnected from the bridge for a time sufficient to allow the cathodes to cool to approximately ambient temperature. For the usual commercial fluorescent lamps, a waiting period of approximately 30 to 60 seconds is generally sufficient.

The voltage supply is then reconnected across the bridge terminals and the maximum deflection of the indicator 7 is noted during the time interval immediately following. The resistances of the tungsten coils of the cathodes may increase over a ratio of as much as 10 to 1 from ambient to equilibrium temperature, due to the positive temperature coefficient of tungsten. Since the bridge was previously balanced with both electrodes hot and at approximately the same temperature and since both electrodes are now starting at ambient temperature, their resistances are originally approximately equal and the bridge is approximately balanced. It will be understood that after a sufficient time interval, both electrodes will reach the previously mentioned equilibrium temperature and the bridge will again be balanced. However, during the course of warming up, the coated electrode of lamp 2, due to its greater thermal mass or inertia, will lag behind the uncoated electrode of lamp 3 in reaching equilibrium temperature; and since it is cooler, its resistance at any instant will be comparatively less. In other words, during the warming-up process, the resistances of the electrodes of lamps 2 and 3 attain a maximum instantaneous deviation. Accordingly, the indicator starts off near balance, reaches a maximum deflection or unbalance, and eventually returns to balance. The deflection of the indicator is noted at maximum unbalance. The maximum deflection of the indicator during the warming-up process is a function of the mass of emission material on the unknown lamp as compared with the known standard lamp.

It is possible to compute directly, by means of mathematical calculations, the weight of emission mix on the electrode of lamp 2 knowing the values of voltage applied to the circuit and the specific thermal capacity of the electrode structures of the lamps. In practice, however, it is more convenient to determine experimentally the significance of the maximum deflection indications by obtaining a range of such deflections for a number of lamps. Afterwards, the weight of emission material on these same lamps is determined experimentally by removing the cathodes and weighing the elements directly in the manner previously described. When a tabulation of sufficient scope has been obtained, a calibration chart may be drawn up and the amount of emission mix on any electrode structure of the same type determined simply by reading the maximum deflection on the indicator and comparing it to the curve on the chart.

The method described in the foregoing paragraphs constitutes the preferred form of my invention. However, it is possible to utilize a simplified procedure, although with some sacrifice in accuracy. According to this simplified procedure, the bridge is balanced with the electrodes cold, and then the maximum momentary unbalance is noted during the course of heating the cathodes by means of a predetermined higher voltage, to a higher temperature. Since both electrodes have approximately the same temperature coefficient of resistance, they would be approximatly balanced at equilibrium at the higher temperature so that approximately the same results are achieved.

Under the usual conditions of manufacturing and production testing, it is highly desirable to have a compact testing equipment by means of which the method may be readily carried out. An indicating unit which may be utilized in conjunction with the bridge circuit of Fig. 1 is illustrated schematically in Fig. 2. This unit is, essentially, a vacuum tube voltmeter of fairly simple design and comprising a transformer 10 whereof the terminals of the primary winding 11 are connected across output conjugate points C—D of the bridge. The secondary winding 12 has a center tap which is grounded and has its outside terminals connected to the anodes of a full wave rectifying tube 13. The cathode of tube 13 is connected to develop a positive unidirectional voltage across a capacitor 14 and a resistor 15 connected in parallel through a limiting resistance 16. This arrangement will be recognized as a full wave detecting system of conventional form, and the purpose of the transformer is simply to convert the bridge impedance to that required for efficient operation of the detecting system. The voltage supplied by the detector tube is provided through a second current limiting resistor 17 to the control grid of one of a pair of pentode tubes 18 and 19. These tubes are connected in similar circuits in parallel across a source of unidirectional voltage indicated by B+ and B−. A micro-ammeter 20 is connected, in series with a sensitivity adjusting resistor 21, across the anodes of the two tubes, and voltage is supplied to the tubes from an adjustable balancing potentiometer 22. The cathodes of the tubes are connected to a source of voltage slightly more negative than ground, as indicated at B+. The control grid of tube 18 is connected to detector 13 as has previously been mentioned, whereas the control grid of tube 19 is connected to ground through a resistor 23. When the bridge is balanced or disconnected from the alternating voltage supply, no voltage appears across terminals C—D; and, accordingly, both tubes 18 and 19 conduct equally so that the deflection on meter 20 is zero. As soon as a voltage appears across points C—D of the bridge, detector 13 causes a positive unidirectional voltage to appear at the control grid tube 18, which increases the conduction through tube

18 and upsets the voltage equilibrium at the anodes of tubes 18 and 19, respectively. Meter 20 thereupon indicates this condition of unbalance which, in turn, is a function of the alternating voltage existing between points C and D and of the unbalance in the bridge.

While my method of determining the amount of emission mix on an electrode has been described involving a comparison with an electrode of a standard lamp which is completely uncoated, it will, of course, be understood that various modifications may be made without departing from the invention. Thus, the electrode of the standard lamp may likewise be coated, or coated to a lesser degree, in which case a comparison may likewise be obtained providing the amount of emission mixture on the unknown lamp is always either greater or lesser than the amount on the standard lamp. However, even where the amounts may vary in either direction, the method may, nevertheless, be carried out by utilizing an indicating system which is sensitive to the direction of unbalance between the points C and D. The appended claims are accordingly intended to cover any such modifications coming within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. The method of determining a figure characteristic of the quantity of emission material on a resistive electrode for a discharge device by means of a Wheatstone bridge apparatus, said electrode having an appreciable temperature coefficient of resistance, which comprises the steps of balancing the bridge with said electrode in the unknown arm and a similar electrode having a known thermal inertia in the standard arm, energizing the bridge to cause said electrodes to tend towards a new thermal equilibrium, and measuring the maximum temporary unbalance of said bridge during the course of attaining said new equilibrium.

2. The method of determining a figure characteristic of the quantity of emission material on a resistive electrode for a discharge device by means of a Wheatstone bridge apparatus, said electrode having an appreciable temperature coefficient of resistance, which comprises the steps of balancing said bridge with said electrode in the unknown arm thereof and a similar electrode coated with a known quantity of emission material in the known arm, said balance being achieved with said electrodes near ambient temperature, increasing the energization of the bridge to cause said electrodes to tend towards a higher thermal equilibrium, and measuring the maximum temporary unbalance in said bridge during the course of attaining said higher equilibrium.

3. The method of determining a figure characteristic of the quantity of emission material on a resistive cathode for a discharge device by means of a Wheatstone bridge apparatus, said electrode having an appreciable temperature coefficient of resistance, which comprises the steps of balancing the bridge with said cathode in the unknown arm and a similar cathode coated with a known weight of emission material in the standard arm, said balance being made with both cathodes at a relatively high thermal equilibrium, deenergizing the bridge apparatus and allowing said cathodes to cool to approximately ambient temperature, and finally reenergizing the bridge apparatus and measuring the maximum unbalance thereof during the course of



reheating said cathodes to said equilibrium temperature.

4. The method of determining a figure characteristic of the quantity of emission material on a discharge lamp resistive cathode having an appreciable temperature coefficient of resistance, by means of a Wheatstone bridge apparatus, which comprises the steps of balancing the bridge with said cathode in the unknown arm and an uncoated cathode of similar construction in the standard arm, said balance being made with both said cathodes at a relatively high thermal equilibrium temperature, de-energizing the bridge apparatus and allowing both said cathodes to cool to approximately ambient temperature, and finally measuring the maximum unbalance of said bridge, after re-energization thereof, during the course of heating said cathodes to said equilibrium temperature.

5. The method of determining a figure characteristic of the weight of emission material on a cathode for electric discharge lamps by means of a Wheatstone bridge apparatus comprising an unknown arm, a standard arm, a pair of ratio arms, and an indicator, said cathode having an appreciable temperature coefficient of resistance, which comprises the steps of balancing said bridge with said cathode connected in the unknown arm and an uncoated cathode of similar construction in the standard arm, said balance being achieved with both said cathodes at a relatively high thermal equilibrium, de-energizing said bridge and allowing both said cathodes to cool to approximately ambient temperature, re-energizing said bridge and noting the maximum unbalance thereof during the course of reheating said cathodes to said high thermal equilibrium temperature.

6. The method of determining a figure characteristic of the weight of emission material on a resistive cathode having a positive temperature coefficient of resistance, by means of a Wheatstone bridge apparatus of the type including a pair of ratio arms, an unknown arm, a standard arm, and an indicator, which comprises the steps of energizing and balancing said bridge with said cathode in the unknown arm and an uncoated cathode of similar construction in the known arm, said balancing being achieved at a relatively high thermal equilibrium, de-energizing said bridge and allowing said cathodes to cool to near ambient temperature, re-energizing said bridge, and measuring the maximum unbalance thereof during the course of reheating said cathodes toward said high equilibrium temperature.

7. The method of determining a figure characteristic of the weight of emission material on a cathode of the filamentary thermionic type having a positive temperature coefficient of resistance, by means of a Wheatstone bridge apparatus of the type including a pair of ratio arms, an unknown arm, a standard arm, and an indicator, which comprises the steps of energizing and balancing said bridge with said cathode in the unknown arm and an uncoated cathode of similar construction in the known arm, said balancing being achieved at a relatively high thermal equilibrium where the resistances of said cathodes are many times greater than their resistances at ambient temperature, de-energizing said bridge and allowing said cathodes to cool to near ambient temperature, re-energizing said bridge, and measuring the maximum unbalance thereof during the course of reheating said cathodes toward said high equilibrium temperature.

8. The method of determining a figure characteristic of the quantity of emission material on a filamentary thermionic cathode for an electric discharge device, said cathode comprising tungsten wire having a high positive temperature coefficient of resistance, by means of a Wheatstone bridge apparatus of the type including a pair of ratio arms, an unknown arm, a standard arm, and an indicator, which method comprises the steps of energizing and balancing said bridge with said cathode in the unknown arm and an uncoated cathode of similar construction in the standard arm, said balancing being achieved with said cathodes at a relatively high thermal equilibrium where the resistances of said cathodes are many times greater than their resistances at ambient temperature, de-energizing said bridge and allowing said cathodes to cool to near ambient temperature, re-energizing said bridge, and measuring the maximum deflection in said indicator as said cathodes increase in temperature toward said high thermal equilibrium, said deflection being caused by unbalance in said bridge due to the thermal lag of said coated cathode over said uncoated cathode causing its resistance to momentarily increase at a lesser rate.

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