

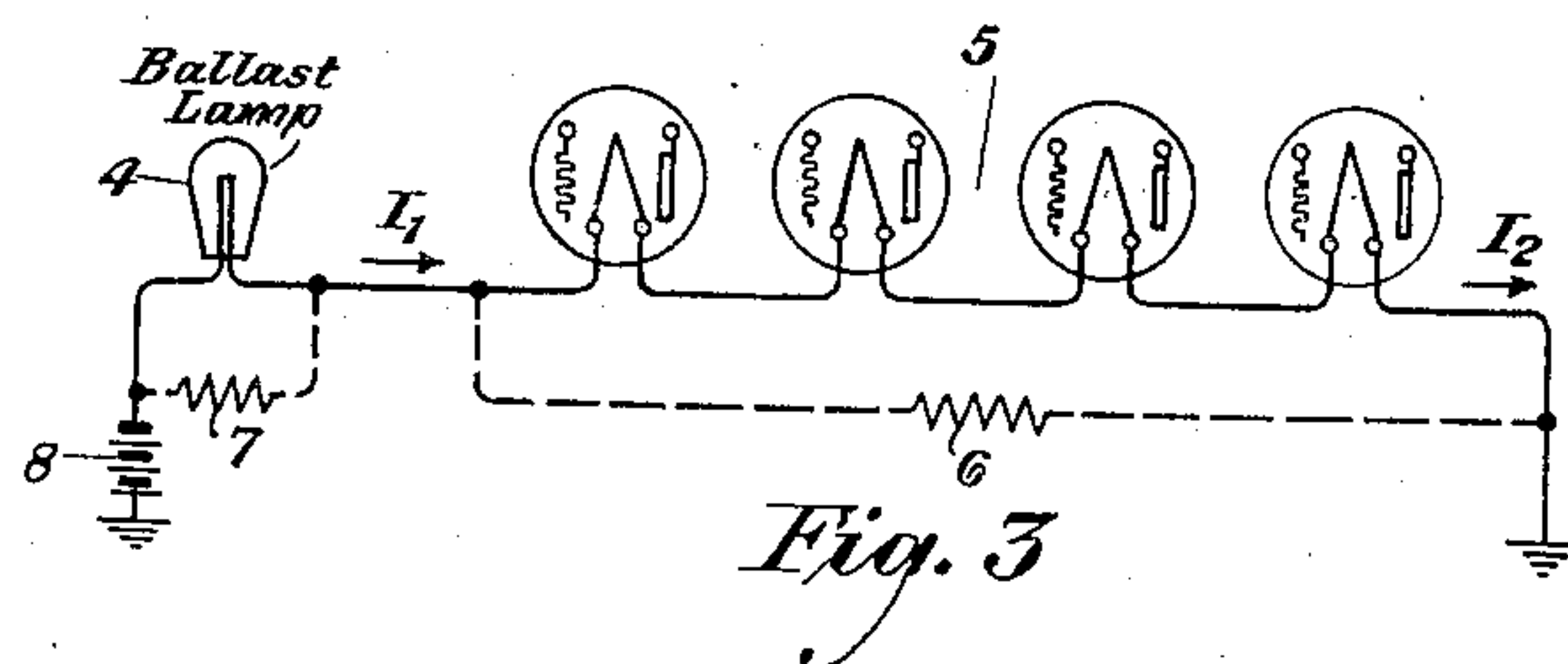
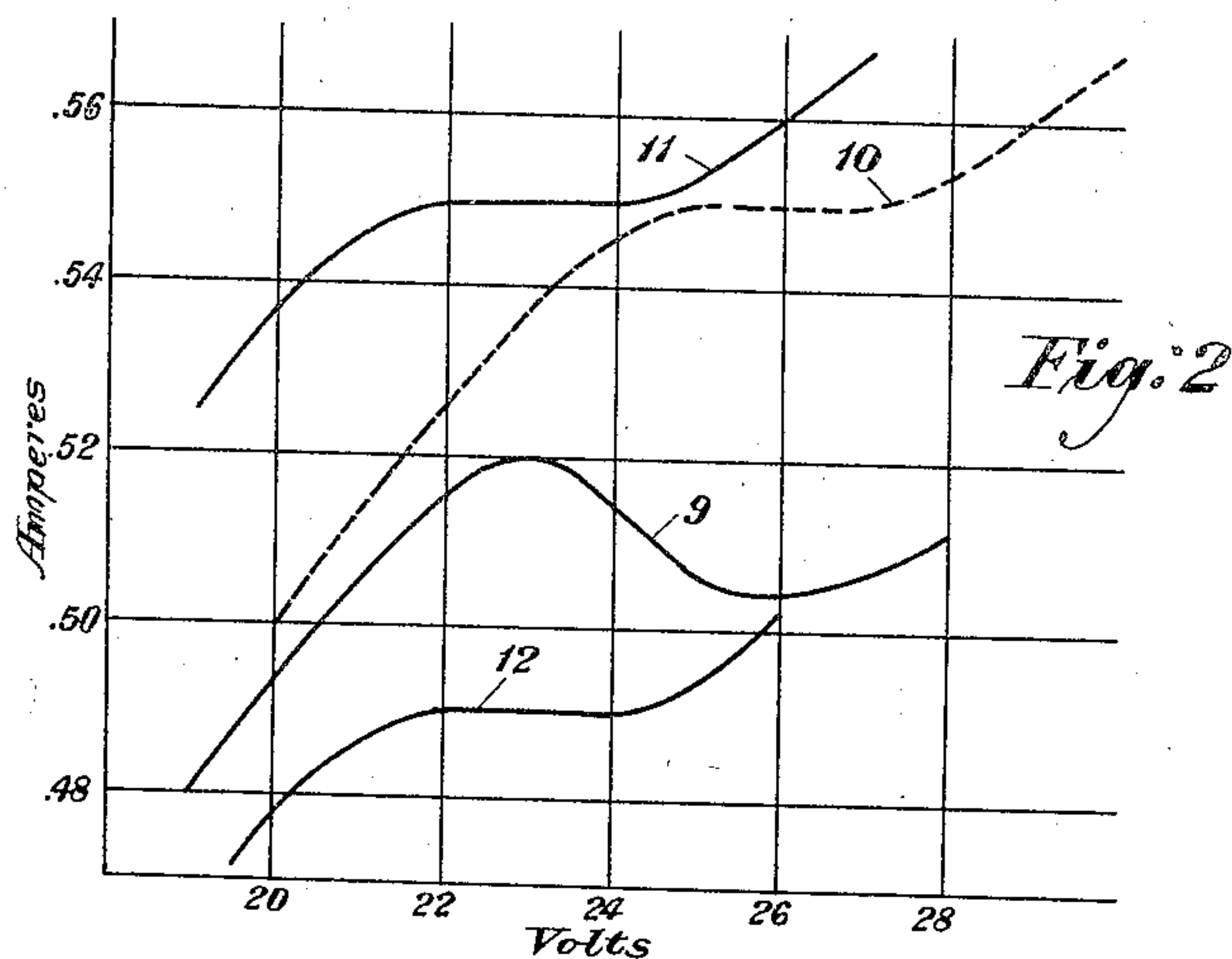
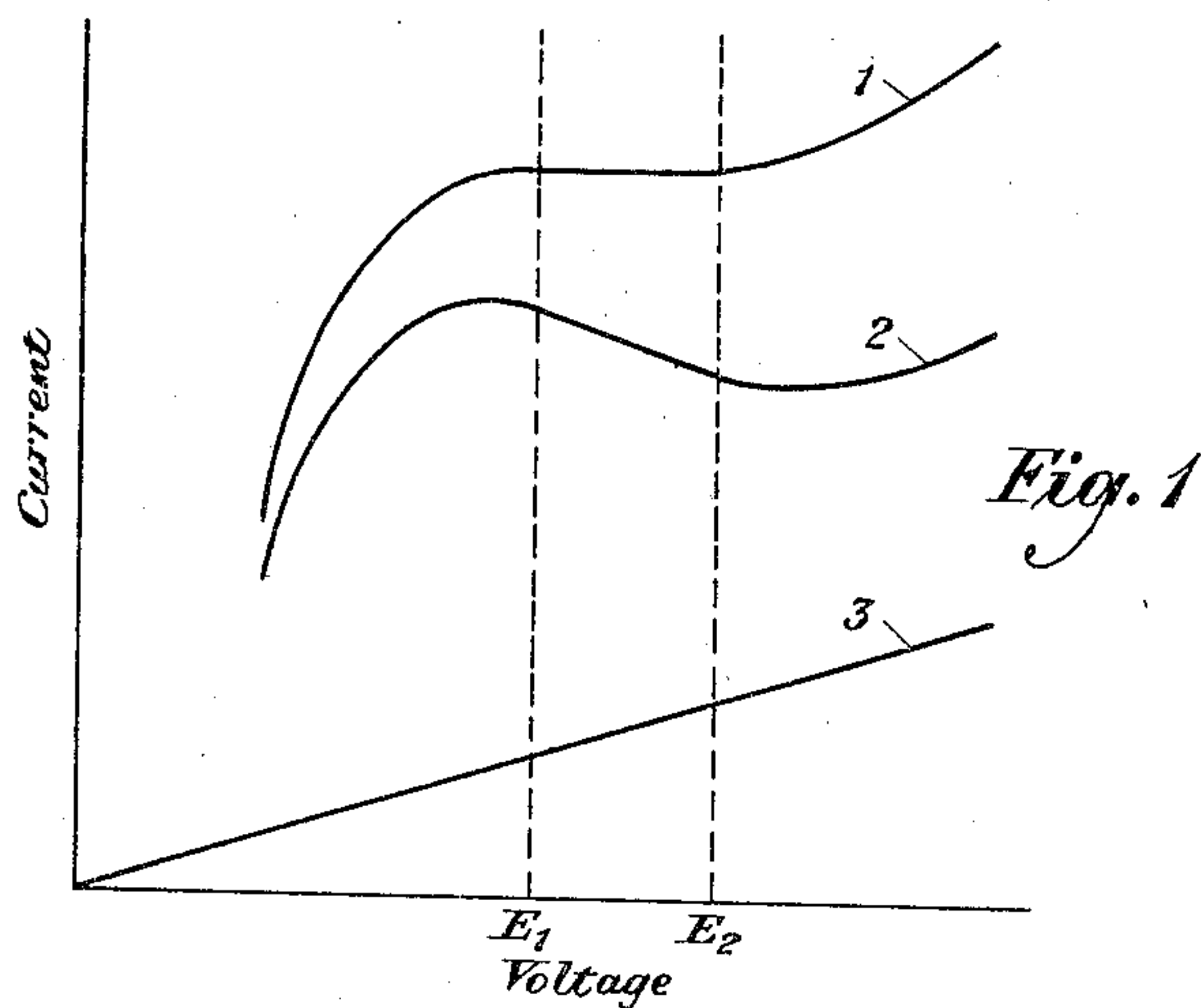
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D. K. GANNETT

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BALLAST LAMP AND FILAMENT ACTIVITY TEST FOR REPEATERS

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INVENTOR  
D. K. Gannett  
BY  
J. H. H. H.  
ATTORNEY



# UNITED STATES PATENT OFFICE

DANFORTH K. GANNETT, OF JACKSON HEIGHTS, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK

## BALLAST LAMP AND FILAMENT-ACTIVITY TEST FOR REPEATERS

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This invention discloses certain tests containing novel features which are applicable to vacuum tube telephone repeater circuits employing ballast lamps to regulate the filament current thereof. These tests have for their object the determination of the useful life of the ballast lamps and vacuum tubes in such circuits.

In accordance with one feature of the invention, the satisfactoriness of the voltage current characteristic of the ballast lamp for filament current regulation is determined by making a single measurement on the lamp while connected in the filament circuit.

In accordance with a second novel feature, the circuit arrangement for testing the ballast lamp efficiency is also applicable in making a filament activity test on the vacuum tubes of the repeater, to determine if the electron emission of such tubes is sufficient under the fluctuating conditions of filament current supply to which such tubes are subjected in operating practice.

In both of the above tests, the novel results are introduced through the use of suitable resistances adapted to shunt the ballast lamp and filament circuit, respectively, the tests being made while the source of voltage supplying the filament current has a value between certain limits.

These features are best explained in conjunction with the drawings, of which Figures 1 and 2 disclose certain current voltage characteristics which are required in an explanation of the tests, while Fig. 3 shows the circuit arrangement for making the tests.

In contemplating the use of ballast lamps to regulate the filament current of telephone repeaters, a difficulty presents itself in the matter of testing the lamps to determine when they have reached the end of their useful life for such purpose. Referring to Fig. 1, a typical current voltage characteristic for a ballast lamp comprising a filament of iron wire immersed in hydrogen at low pressure is shown by curve 2. As the lamp ages, a gradual change in gas pressure causes the characteristic curve to drift uniformly downward to smaller current values. A condition is thus reached at which the lamp is no longer

satisfactory as a ballast resistance in the filament circuit of a repeater. Tests must therefore be made from time to time, to determine when the lamp characteristic has fallen below a certain limiting minimum level. It is difficult to devise a practical test based on individual current and voltage readings to determine the amount of drift in lamp characteristics, due to the fact that at a given battery voltage, various lamps may be at different points on their characteristic curves.

It will be noted, however, referring to curve 2, Fig. 1, that between the voltage limits  $E_1$  to  $E_2$  the curve has an approximately constant negative slope, i. e., the current decreases at a constant rate as the voltage is increased. Suppose, now, that the lamp is shunted by a resistance having a current voltage curve of slope equal in magnitude to this negative slope. The result will be a parallel circuit arrangement which causes a constant total current flow between the voltage limits  $E_1$  to  $E_2$ . Curve 3, Fig. 1, shows the current voltage curve of such a resistance, while curve 1 shows the total current taken by the parallel circuit i. e., lamp + resistance. Curve 1 is obtained by adding the ordinates of curves 2 and 3, and, as will be seen, the current is constant between the voltage limits  $E_1$  to  $E_2$ . The significance of curve 1 lies in the fact that anywhere within the voltage range  $E_1$  to  $E_2$  a single current reading indicates definitely the amount of drift of the lamp characteristic.

This last factor is of especial value in testing ballast lamps used in repeater circuits, as will now be pointed out. In Fig. 3, the full lines show in schematic form the wiring of the filament circuit of a telephone repeater. The amplifier tubes are shown at 5 with the filaments connected in series having one end grounded and the other end connected to the ballast lamp 4. The ballast lamp in turn is connected to the source of voltage 8. The resistances 6 and 7 are normally not part of the circuit and are used in making the tests as is explained below.

In making measurements on the ballast lamp, it is, of course, desirable that the re-



peater circuit of Fig. 3 be disturbed as little as possible. The test could very simply be made by shunting the ballast lamp with a suitable equalizing resistance 7, to maintain the current constant between certain voltage limits, applying a suitable voltage at 8 and measuring the current  $I_1$ . The battery voltage 8 can not easily be adjusted to a predetermined value. On the contrary, it is subject to considerable fluctuation from time to time due to the charge and discharge of the battery, the total load resistance connected, and the like. The result is that the observer must select an interval when the battery is at the proper voltage and then make the measurement on the ballast lamp. In this respect, he is aided considerably by the fact that the measurement may be made at any voltage within the range  $E_1$  to  $E_2$ , Fig. 1. This fact constitutes a second and principal reason why it is advantageous to equalize the ballast lamp with a suitable shunt resistance 4 before measuring. The measurement, of course, merely consists in measuring the current  $I_1$ , with resistance 7 connected and a suitable voltage applied at 8. If the current is less than a certain minimum value, the lamp 4 is no longer suitable for use in the repeater circuit.

The resistance of the filament circuit 5 in series with the shunt circuit comprising the lamp 4 and resistance 7 merely has the effect of making the flat portion of the current voltage curve occur at a higher voltage than would be the case with the filaments omitted.

Referring to Fig. 2, curve 9 shows the characteristic curve for ballast lamp 4 and filament circuit 5 alone. The constant negative slope occurs between 23 and 25 volts for this particular case which is fairly representative. Shunting lamp 4 with a suitable equalizing resistance 7 gives the characteristic shown by curve 10. The total current for a given voltage is naturally increased due to the lowering of the total resistance by addition of the shunt. Also, the flat portion of the curve occurs at a higher voltage than the negative slope of curve 9, since more voltage is now required to send the same current as formerly through lamp 4, due again to the shunting effect of resistance 7. In order to cause the flat portion of the curve to occur in a lower voltage range and also to prevent large values of current from flowing through the filaments, a resistance 6 is shunted across the filament circuit 5. The total current voltage curve for this condition is shown by curve 11, Fig. 2. The corresponding current through the filaments only, namely  $I_2$ , is shown by curve 12.

The circuit arrangement of Fig. 3 suggests the possibility of combining the filament activity test for the vacuum tubes 5 with the test on the ballast lamp. The filament activity test consists in determining the change in

gain of the repeater caused by fluctuations of the filament current resulting from the voltage changes of the source of potential encountered in operating practice. For repeater use, a vacuum tube reaches the end of its useful life when, under the current fluctuations encountered in operating practice, its change in gain exceeds a specified amount. For the typical repeater installation of the type here considered, the voltage will normally fluctuate from about 20 to 28 volts over a period of time. Referring to curve 9, Fig. 2, showing the results for ballast lamp and filament circuit only, a fluctuation between such voltage limits will cause the current to vary from about .49 to .52 ampere. Resistances 6 and 7 of Fig. 3 were selected to cause the flat portion of curve 12, which gives the current in the filament circuit 5, to have this minimum value of .49 ampere and to occur between the voltage limits 22 to 24 volts, which is the voltage range for which the filament current is normally a maximum, as shown by curve 9.

Hence, to make tests on both the ballast lamp as well as vacuum tubes, the operator merely selects an interval when the battery voltage lies between 22 and 24 volts. With resistances 6 and 7 disconnected, giving the filament current  $I_2$ , of curve 9, the repeater gain is measured. Resistances 6 and 7 are now connected, as shown in Fig. 3, giving the filament current  $I_2$  corresponding to curve 12, and the repeater gain again measured. The difference of the readings gives the change in gain. If this exceeds a specified maximum, the tubes should no longer be used. With the resistances connected, the total current  $I_1$  is also measured, which gives a point on curve 11 between 22 to 24 volts. If this current is less than a specified minimum, the ballast lamp has reached the end of its useful life.

It is realized that in order for the ballast lamp test described above to be effective, there must be considerable uniformity in the characteristics of such lamps. An inspection of a number of such characteristics indicates sufficient uniformity among them to make the testing methods proposed, effective. There is apt to be some variation in the resistances of the different filament circuits. However, if the different filament circuits are equalized roughly to the same resistance, by inserting resistance in series with filament circuit 5, Fig. 3, there will be a range of a volt or so in the battery voltage in which this test may be applied with the assurance that all lamps will be at the proper place on their characteristics.

In order to carry out the test, it is necessary that at least five or ten minutes' time elapse between the connection of the resistances to the circuit and the making of the readings, due to the sluggishness of the ballast lamp in adjusting itself to the new cur-



rent conditions. For this reason, it is necessary either that every filament circuit be provided with the necessary resistances which may be connected for a test or that a sufficient number be provided external to the filament circuits so that say twenty repeater circuits may be arranged for test at one time.

What is claimed is:

1. The method for determining the voltage current characteristic of a ballast resistor which consists in shunting the same with a fixed resistance such that the current taken by the parallel circuit is constant between certain voltage limits, and measuring said total current by applying a voltage between said limits.

2. The method for determining the voltage current characteristic of a ballast lamp comprising an iron wire filament immersed in hydrogen at low pressure which consists in shunting the lamp with resistance such that the total current in the parallel circuit is constant between certain voltage limits, and measuring said total current with an applied voltage lying between said voltage limits.

3. The method for determining the change in the voltage current characteristics of a ballast resistor due to aging, which consists in shunting the same with a resistance such that the total current taken by the shunt circuit is constant between certain limits of applied voltage, measuring said total current when the applied voltage lies between said limits, and comparing said measurement with a predetermined standard of reference.

4. The method for comparing the current voltage characteristics of ballast resistors, which consists in shunting a given resistor with a fixed resistance such that the total current flowing in the parallel circuit is constant between certain distinct limits of applied voltage, measuring said total current for a single value of applied voltage lying between said limits, and referring the measurement thus obtained to some standard of reference.

5. Means for comparing the current voltage characteristics of ballast lamps comprising a resistance adapted to be connected in shunt with a given lamp, said resistance being of such value as to cause the total current taken by the parallel circuit to remain constant between certain distinct limits of applied voltage, a source of potential for applying a voltage between said limits, and means for measuring the total current in the parallel circuit with said voltage applied.

6. The method for locating the current voltage characteristic of a ballast lamp, which consists in shunting said lamp by a resistance having a current voltage curve of slope equal in magnitude to the negative slope of said ballast lamp characteristic between certain voltage limits, applying to said shunt circuit

a voltage between said limits, and measuring the total current in the shunt circuit.

7. In a vacuum tube amplifier, the filament current of which is subject to fluctuation between certain limits, the method of determining the change in amplifier gain due to such current fluctuation, which consists in selecting an interval when the filament current is an approximate maximum, and measuring the amplifier gain, shunting the filament circuit with resistance to reduce the filament current to a minimum, and again measuring the amplifier gain.

8. In a vacuum tube amplifier, the filament current to which is regulated by a ballast resistor inserted therein, a combined test for measuring the change in amplifier gain due to fluctuation of filament current, and for locating the current voltage characteristic of the ballast lamp, which consists in applying to the filament circuit the voltage causing the approximate maximum current to flow therein and measuring the amplifier gain, shunting the ballast resistor with one resistance and the filaments with another resistance such that the filament current has its approximate minimum value and is constant between certain voltage limits which include the above applied voltage, again measuring the amplifier gain and also the total current flowing in the circuit.

9. In a telephone repeater, the filament current to which is regulated by a ballast lamp inserted therein, a combined test for determining the change in repeater gain due to filament current fluctuation and for locating the current voltage characteristic of the ballast lamp, which consists in selecting an interval when the filament current has its approximate maximum value, measuring the repeater again, shunting the ballast lamp with resistance and the filaments with other resistance such that the filament current has its approximate minimum value and is constant between certain limits of the source of voltage including that inducing the flow of the above maximum filament current, again measuring the repeater gain and also the total current flowing in the circuit.

In testimony whereof, I have signed my name to this specification this 12th day of September, 1928.

DANFORTH K. GANNETT.

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