May 5, 1931. H. A. JONES 1,804,344

BALLAST RESISTOR

Filed April 20, 1927

Fig. 1.

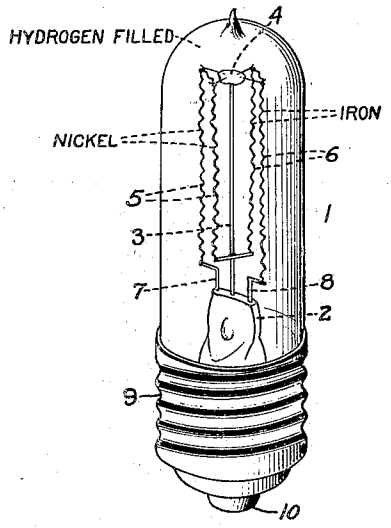
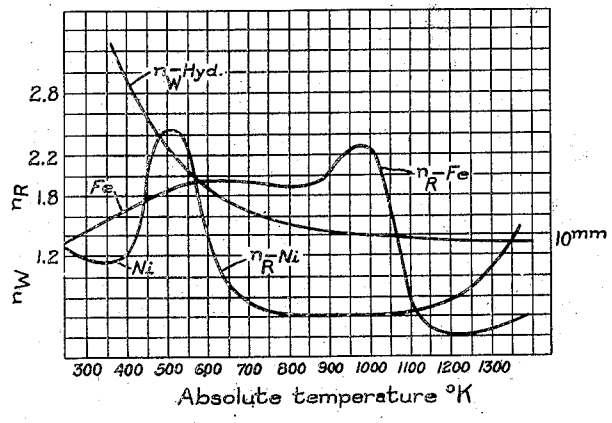


Fig. 2.



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UNITED STATES PATENT OFFICE

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BALLAST RESISTOR

Application filed April 20, 1927. Serial No. 185,316.

The present invention relates to resistance elements of the type commonly known as ballast resistors. The use of ballast resistors to provide a substantially constant current is well known. Iron ballast resistors, for example, have been employed in hydrogen at low pressures and have given a good flat characteristic at the desired current over a long voltage range. In employing iron resistors however at the upper temperature limit of ballast action and with low gas pressures, it is found that the iron evaporates at such a rate that the life of the resistor is but little better than that which may be obtained by employing iron in a vacuum, that is, approximately 1000 hours at 1100° absolute temperature.

It is particularly desirable in many cases to employ ballast resistors in connection with devices which necessitate having the ballast resistor underground. Such a location, of course, renders it difficult to replace a resistor and makes it very desirable to employ resistors having a relatively long life.

It is one of the objects of my invention to provide a ballast resistor capable of operating at relatively low gas pressures as, for example, 1.0 millimeter to 10 millimeters and over a long voltage range, for prolonged periods of time without deterioration of the resistor.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, will best be understood from reference to the following specification when considered in connection with the accompanying drawings in which Fig. 1 shows a perspective view of a gas filled receptacle and resistor embodying the features of my invention; while Fig. 2 illustrates the ballast action of the resistor in a hydrogen atmosphere at 10 mm. pressure.

Referring to the drawings, I have indicated at 1 a glass container from which air has been evacuated and which is filled with an inert gas such as hydrogen or helium at a pressure which may vary from 1.0 to 10 mm. of mercury. The container is provided with a reentrant stem portion 2 carrying a metal support 3 to which an insulator 4 is attached. A wire resistor comprising a nickel portion 5 in series with an iron portion 6 is supported from insulator 4 and supplied with current through leading-in wires 7 and 8 connected respectively to the screw collar 9 and a contact 10. The connection of a nickel wire of the proper diameter in series with an iron wire provides a resistor having a ballast action over a long voltage range. Such a resistor has a life, based on the evaporation of the filament, which is about 40 to 50 times greater than that obtained by an iron resistor alone in a hydrogen atmosphere. The ballast action of the nickel wire begins at a point which is about 100° C. lower in temperature than the point at which the ballast action of the iron will begin. At the point where the ballast action of the nickel ceases the iron starts to ballast at its lowest temperature point and continues to a point which may be chosen about 100° lower than that of its upper limit. This 100° reduction in the upper temperature limit of the iron reduces the rate of evaporation of the iron to such an extent that the life of the resistor is at least forty times greater than that obtained when iron alone is employed as the resistor.

The ballast action of the nickel and iron wire is illustrated in Fig. 2. It has been shown in the General Electric Review of May, 1925, that the volt-ampere characteristic curve for an iron wire resistance operating in hydrogen will exhibit "ballast action" (i. e., the current will remain constant over a wide range of voltage), if the total heat loss in watts (W) from the resistance increases less rapidly with the absolute temperature than the resistance (r).

Since W, the total heat loss in watts from a filament operating in a gas, and R, the resistance of the filament at the operating temperature, are both functions of the temperature, over any small interval of temperature

$$W = AT^{n_W}$$

and

$$R = BT^{n_R}$$

Here n_W and n_R are the exponents of the

absolute temperature with which W and R increase with the absolute temperature.

The above equations may be written

$$n_W = \frac{d \log W}{d \log T} = \frac{T\, dW}{W\, dT}$$

and

$$n_R = \frac{d \log R}{d \log T} = \frac{T\, dR}{R\, dT}$$

Ballasting will occur with a wire operating in a gas when

$$n_W - n_R < O$$

Hence, if n_W and n_R are plotted as functions of temperature the n_W curve will lie below the n_R curve in the temperature region in which the last mentioned equation is satisfied, i. e., from such a plot we can obtain the filament temperature range in which ballasting will occur. The portions of the n_W line for hydrogen at 10 mm. which lies below the n_R lines indicate the range of ballast action for the elements nickel and iron employed in the resistor, and it will be observed that the iron ballast action commences exactly at the termination of the nickel ballast action. The same operation would follow with gas pressures of 1.0 mm., although in the latter case the diameter of the nickel and of the iron wires employed will be somewhat larger than that employed at 10 mm. pressure in order to obtain the same ballast value of current.

As a ballast resistor the metal, nickel, has several advantages over iron. For example, the life factor based on evaporation in the case of nickel at the upper end of its ballast range is about 10^{10} times in favor of the nickel over iron at the upper end of its ballast range. Moreover nickel does not crinkle and shrink in length upon passing through any critical temperature either below, in, or above its ballast region as happens with iron at 100° above its ballast region.

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

1. A ballast device comprising a nickel resistor and an iron resistor connected in series.

2. In combination, a receptacle filled with an inert gas at a relatively low pressure, and a ballast device mounted therein, said ballast device comprising a pair of series connected nickel and iron resistors.

3. In combination, a receptacle filled with an inert gas at a pressure varying from about 1 to about 10 millimeters of mercury and ballast device mounted therein, said device comprising a nickel resistor connected in series with an iron resistor.

4. In combination, a receptacle filled with hydrogen at a pressure varying from about 1 to about 10 millimeters of mercury and a ballast device mounted therein, said device comprising a nickel resistor connected in series with an iron resistor, means whereby an electromotive force may be applied to said device, said resistors being adapted to act successively as ballast resistors as the electromotive force impressed upon said device varies.

In witness whereof, I have hereunto set my hand this 19th day of April, 1927.

HOWARD A. JONES.