No. 820,365. PATENTED MAY 8, 1906.

D. McF. MOORE.

VACUUM TUBE REGULATOR.

APPLICATION FILED FEB. 7, 1906.

2 SHEETS—SHEET 1.

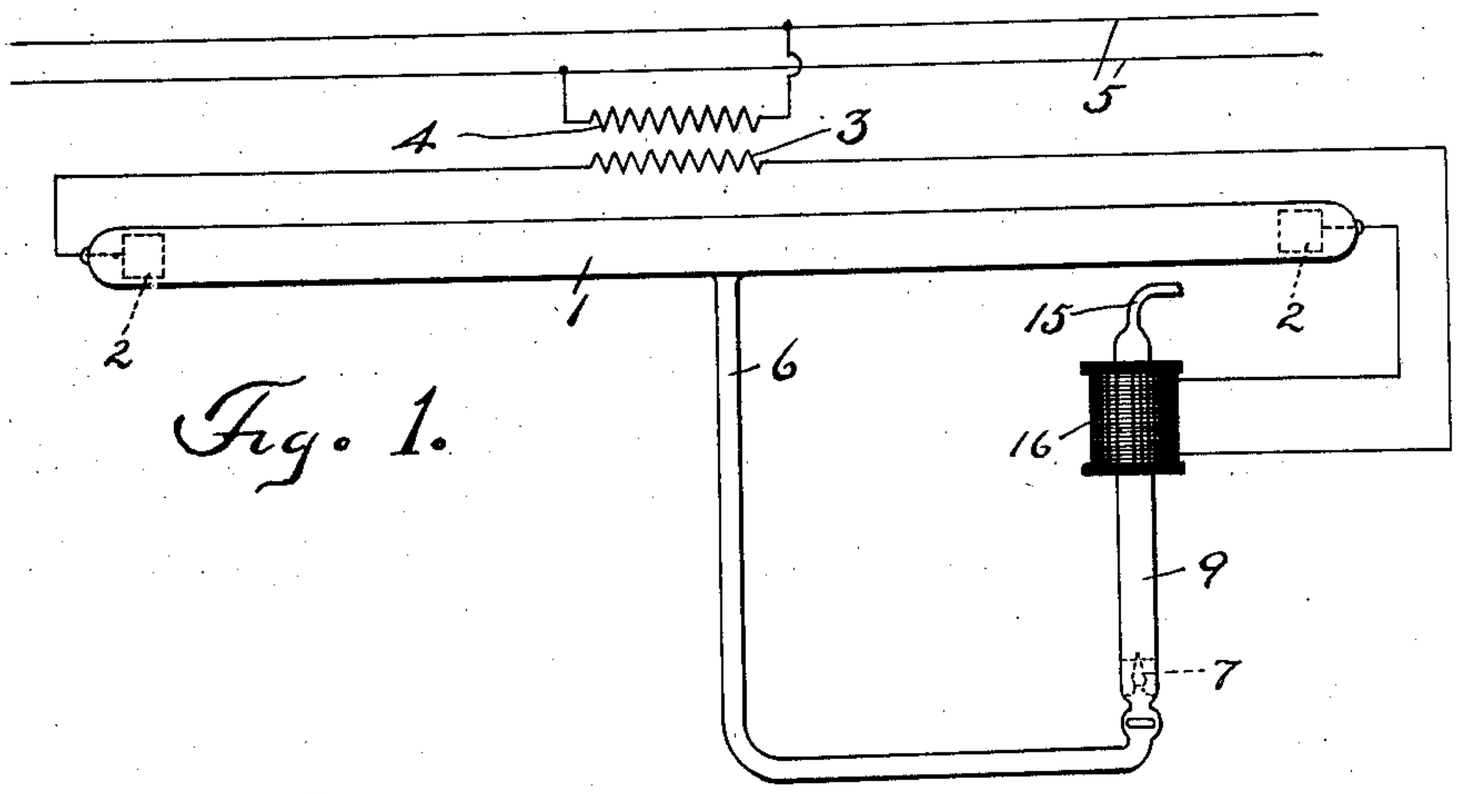

Fig. 1.

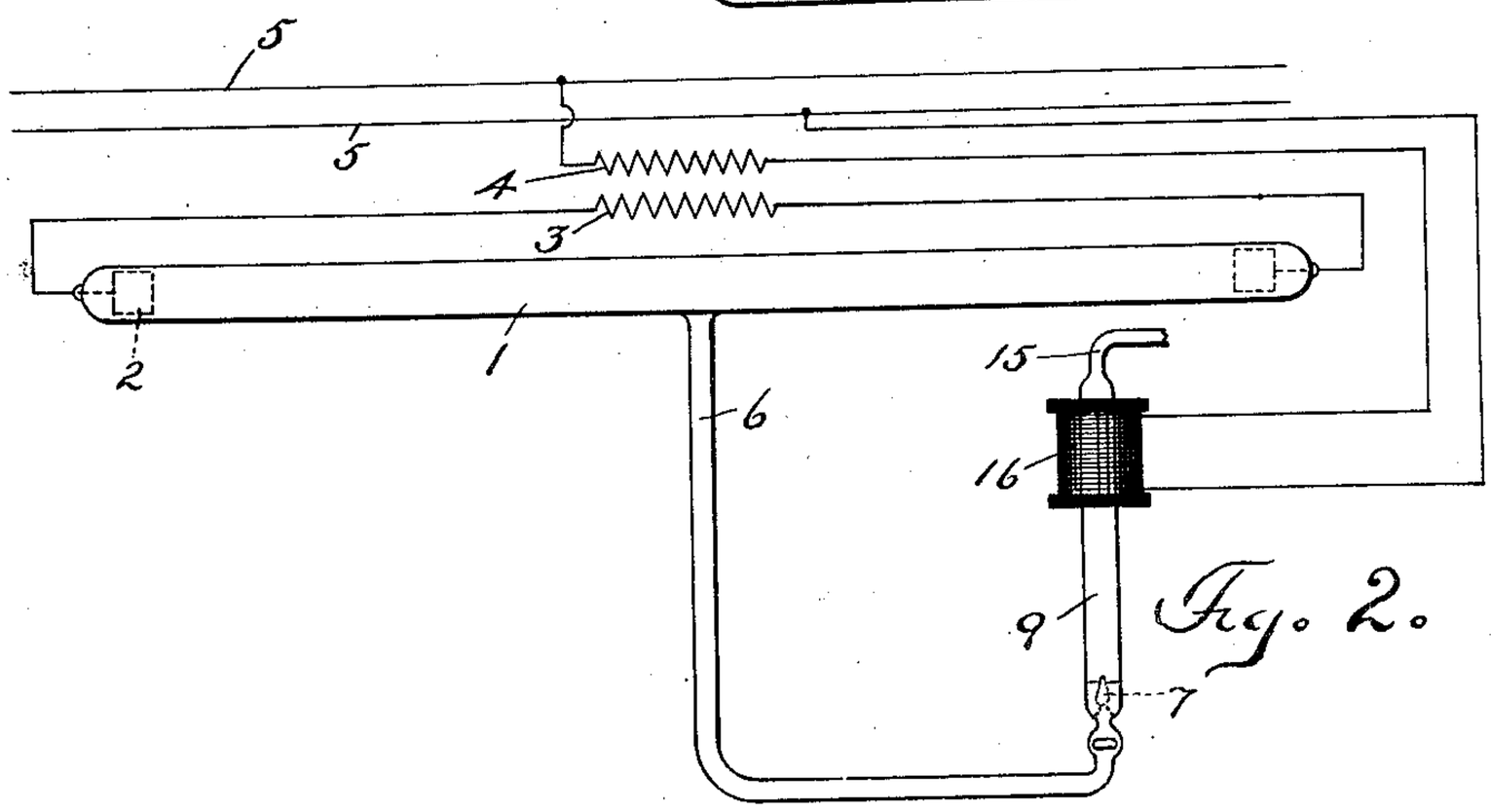

Fig. 2.

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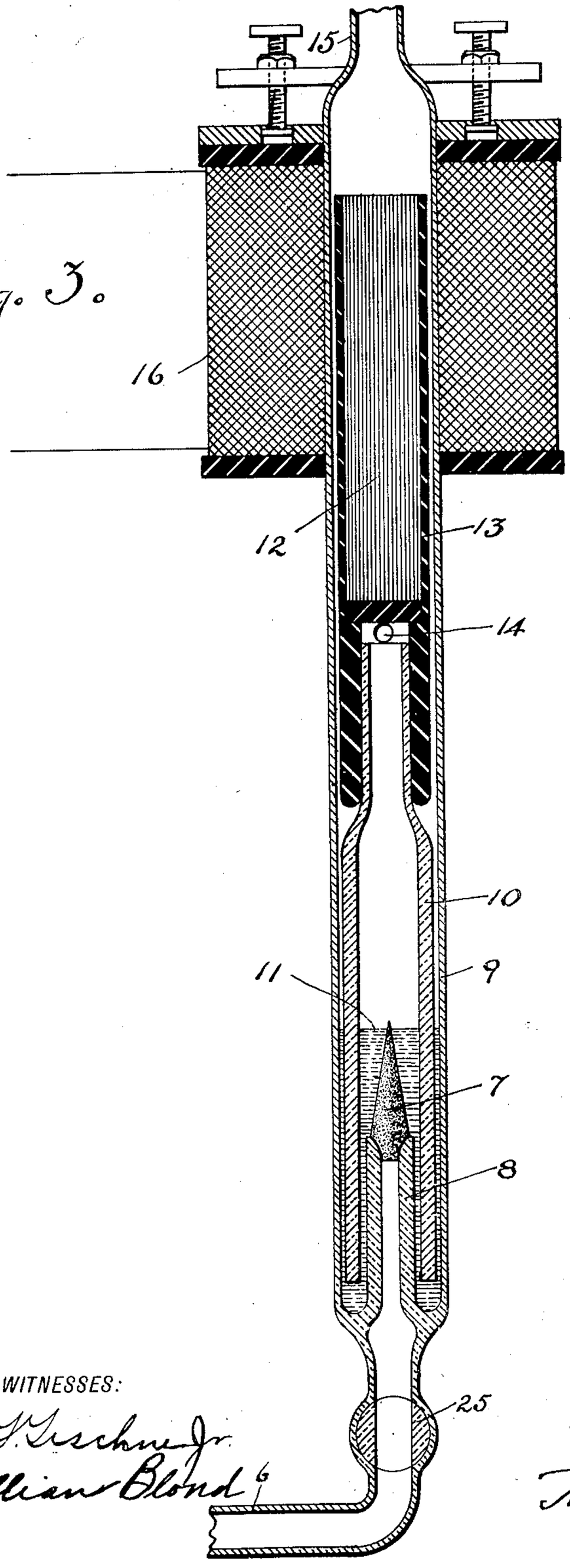
2 SHEETS—SHEET 2.

Fig. 3.



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UNITED STATES PATENT OFFICE.

DANIEL McFARLAN MOORE, OF NEWARK, NEW JERSEY, ASSIGNOR TO MOORE ELECTRICAL COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

VACUUM-TUBE REGULATOR.

No. 820,365. Specification of Letters Patent. Patented May 8, 1906.

Original application filed August 21, 1905 Serial No. 275,003. Divided and this application filed February 7, 1906. Serial No. 299,883.

To all whom it may concern:

Be it known that I, DANIEL MCFARLAN MOORE, a citizen of the United States, and a resident of Newark, in the county of Essex and State of New Jersey, (whose post-office address is 52 Lawrence street,) have invented certain new and useful Improvements in Vacuum-Tube Regulators, of which the following is a specification.

The present invention relates to vacuum-tube or vapor electric lamps, vacuum or vapor rectifiers, X-ray tubes, vacuum oscillographs, wireless-telegraph receivers, and other devices which are provided with suitable electric terminals whereby electric energy may be passed through the gaseous contents of the tube for any purpose and which generally may be classified under the head of vacuum-tubes.

The present application is a division of my prior application filed in the United States Patent Office August 21, 1905, Serial No. 275,003, and relates more particularly to a method of maintaining a constancy in the tension or condition of the gas within the tube.

The invention is of special utility in maintaining the gaseous tension or condition in vacuum-tube lamps, and has for its object, generally speaking, to remove the difficulty hitherto met with in the operation of this general class of apparatus from deterioration or variation of the vacuum or gaseous or vapor tension, or, in the case of lamps, from the gas becoming spent or losing its light giving and conducting function as the vacuum gets higher. Hitherto when the tube fails through change of the gaseous tension or gaseous condition it has been necessary in this art to either open the tube and renew the contents and then reëxhaust the same or else to provide within the tube some solid material which would act as a generator or regenerator of gas to automatically repair the impaired vacuum.

Briefly stated, the invention consists in automatically maintaining the vacuum in a vacuum-tube at a substantially constant degree by feeding gas to the tube from a body of gas having a higher density or tension than that to be maintained in said tube and regulating or determining the rate of feed automatically by changes in the vacuum or gas tension within said tube.

In carrying out my invention the feed at the required rate may be continuous or an intermittent feed, and, as will be obvious, the density of the body of gas which is fed or admitted to the tube at the regulated rate may be anything above the normal low pressure or density maintained in the tube. The changes in the gaseous tension or density within said tube may be made effective in any desired way and by any desired devices controlled or operated automatically in response to or in accordance with the variations of such gaseous tension in said tube.

Preferably in carrying out my invention I employ a feed device in the nature of a valve which is interposed in a passage between the body of gas of higher density and the tube in which the lower tension or higher vacuum is to be maintained. As a valve illustrated, I show a form of valve in another application for patent filed by me August 21, 1905, Serial No. 275,003, and comprising substantially porous material, through which the gas from the source is permitted to percolate in amounts determined by the level of a sealing liquid in which the mass of porous material is immersed. While it is possible to utilize the changes in tension of the gas within the vacuum-tube in various ways, I prefer to show them as made effective through the operation of an electromagnet responsive to changes in the resistance of the gas which accompany such changes of tension.

My invention is particularly useful as a method of maintaining a constant luminosity in vacuum-tube lamps, and when employed for this purpose it is preferable to keep the density or tension in the tube at such a degree that a decrease of the density will have the effect of lowering the resistance of the gas to the passage of an electric current. The magnet may be made to respond directly or indirectly to the changes of electrical resistance in the tube by connecting it into circuit in any desired way. When the tube is operated from a transformer, it may be placed either in the primary or the secondary circuit of said transformer. When so connected, a decrease in the resistance to the passage of the current through the gas in the tube consequent upon a decrease of the density, or, in other words, an increase of the

vacuum, will cause more current to flow in the magnet and strengthen the same. This increase of strength in the magnet is employed to operate upon any suitable devices, such as the valve, in such way as to admit more gas to the tube, and thus bring the vacuum back to normal, whereupon the strength of the magnet decreases and the flow or admission of gas from the source is automatically cut off.

In the accompanying drawings, Figure 1 illustrates diagrammatically an arrangement of circuits and devices suitable for practicing my invention. Fig. 2 shows a modification in the manner of connecting up the magnet. Fig. 3 is a vertical section through the electromagnet and a form of valve that may be employed.

The invention will be herein described as carried out in connection with a vacuum-tube lamp in which air or any other gas is employed.

1 is the tube of glass, and 2 the internal electrodes joined to conductors sealed in the tube and furnished with electric energy supplied from any source—as, for instance, the secondary 3 of a transformer the primary 4 of which is connected to the mains 5.

At 6 I have indicated a pipe sealed to the tube 1 at any point through which pipe the gas is fed in the required amount into the lamp and which tube leads from any body or source of gas of greater density than that in the tube.

Referring to Fig. 3, 7 indicates a mass of any porous material—as, for instance, carbon—which is sealed like a stopper in the end of a tube 8, joined or leading to pipe 6 and the lamp. The exposed end of the plug or mass 7 is located in a chamber 9, wherein is maintained a pressure of air or other gas suitable for use in the lamp. Tubes 8 and 9 are preferably concentric and are arranged, as shown, to form an annular chamber which receives the lower end of a plunger or liquid-displacer 10, and in the chamber 9 is a body of liquid consisting of mercury or other liquid which surrounds the mass of porous material 7, leaving the upper terminal of the same exposed or adapted to be exposed by a slight change of level of the liquid 11, brought about in any way—as, for instance, by the operation of the displacer 10, which for that purpose can be suspended from the core 12 of an electromagnet. By moving the displacer the tip of the mass 7 may be more or less exposed or by a suitable adjustment may be alternately exposed and sunk beneath the level of the liquid, so as to vary the extent of the porous surfaces through which gas under pressure may leak into and through the mass 7. The plunger 10 is preferably of glass, like chamber or tube 9, to permit the plug 7 and the position of its tip in the liquid to be observed. The plunger or displacer may be attached to the core 12 by means of indurated-fiber tube 13, which carries core 12 of iron wires. The space within the cylindrical displacer 10 is in communication with any source or body of gas under pressure—as, for instance, the atmosphere—through a hole 14, communicating with the spaces in the tube 9, which latter receive the air or other gas through pipe 15. An adjustment of the vertical position of the displacer to determine the extent to which the tip of the mass 7 shall be normally exposed above the level of the liquid may be secured by adjusting the position of the coil 16 of the electromagnet vertically on the tube 9. Mercury is preferred, because it forms an effective air seal and does not clog the pores of the porous mass 7.

The coils 16 of the electromagnet may be connected in a variety of ways, so as to feel the effect of a change of resistance within the lamp. As shown in Fig. 1, they may be in series with the lamp and secondary coil; but they might be in series with the primary core when the lamp is operated on a constant potential system. They might, as well understood in the art, be connected in other ways to the circuit of the translating device. As is well known, there is a critical tension or degree of vacuum in the tube, at which the resistance to the passage of electric energy through the gas from one electrode to the other of the tube is at its lowest. If the vacuum increases beyond this critical point, the resistance increases and the current falls. It is preferable to operate the tube below the degree of vapor or gas tension at which the resistance and current change from a decreasing value of current to an increasing value of resistance and decreasing value of current; but for economy the degree of vacuum should be maintained as near as possible to the point where the resistance is least, though sufficiently below such point to avoid the possibility of changes of tension extending over to the degree where the resistance will increase with an increase of the vacuum. In the operation of the apparatus when the vacuum in the lamp deteriorates slightly through continued action of the electric energy upon the gaseous contents the resistance decreases and slightly more current flows through the magnet, which thereupon causes the height of the liquid-level to fall by lifting the displacer 10. This permits gas to flow through the tip of the plug or pencil 7 into the lamp until the normal gaseous condition therein is restored and the tube is made to conduct less current, so that the magnet will let the displacer 10 fall again.

By adjustment of the magnet any desired degree of vacuum in the tube or any desired degree of intensity of light can be maintained within narrow limits.

25 is a suitable stop-cock in the connection

between feed-tube 6 and the valve. Fig. 2 shows simply a modification of the circuits wherein the magnet is connected to the primary instead of to the secondary of the transformer.

My invention is applicable not only to lamps having internal electrodes, but also to those having external electrodes wherein the energy is transmitted by electrostatic induction to the contents of the lamp.

It is obvious that my invention is applicable to tubes supplied either with alternating or direct currents.

In the foregoing description and in the claims appended the term "gas" is to be understood as including the aeriform condition of any solid or liquid and commonly known as "vapor."

The constructions of apparatus shown in the present case as one of the forms of apparatus or devices suitable for use in practicing my invention are not herein claimed, as they form the subject of claims in my application, filed August 21, 1905, Serial No. 275,003. The special construction of valve is not herein claimed, but forms the subject of a separate application for patent filed by me April 16, 1906, Serial No. 311,816.

What I claim as my invention is—

1. The method of maintaining a constant luminosity in a vacuum-tube by feeding gas thereto from a body of gas maintained at a density greater than that within the tube and regulating the amount fed by changes of the density of gas within said tube.

2. The method of maintaining the vacuum in a vacuum-tube at any desired tension by feeding gas thereto from a body of gas maintained at a density greater than that within the tube and adjusting the admission of gas from said body of gas by variations in the electrical resistance of the gas within the tube.

3. The method of maintaining the luminous condition of a vacuum-tube lamp at its normal by regulating the admission of gas to said lamp through variations in the electrical resistance of the gas within the tube accompanying changes in luminosity.

4. The herein-described method of maintaining a constant luminosity in a vacuum-tube lamp, consisting in maintaining the vacuum at such degree of tension or density that a decrease of density will have the effect of decreasing the resistance of the gas to the passage of an electric current, utilizing the decrease of resistance to effect a change in the flow of an electric current and employing the changed strength of current to regulate the flow of gas to the tube.

Signed at New York, in the county of New York and State of New York, this 28th day of November, A. D. 1905.

DANIEL McFARLAN MOORE.

Witnesses:

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LILLIAN BLOND.