Feb. 20, 1923. 1,446,247.

L. DE FOREST.

LIGHT CONTROLLING MEANS.

FILED MAR. 16, 1921. 2 SHEETS—SHEET 1.

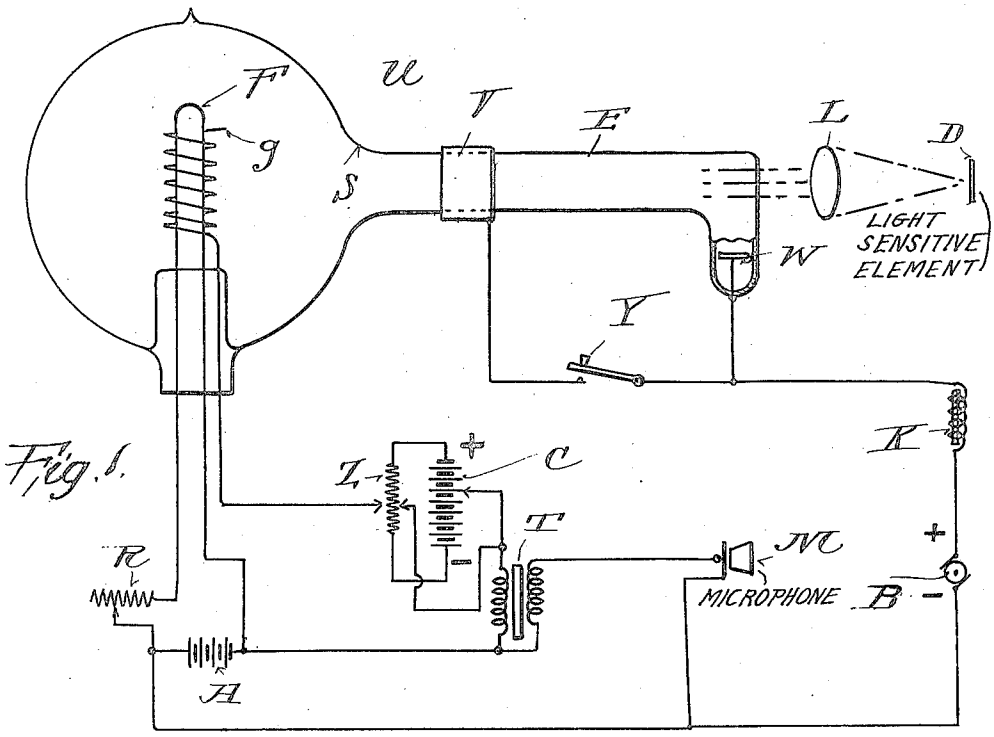



Fig. 1.

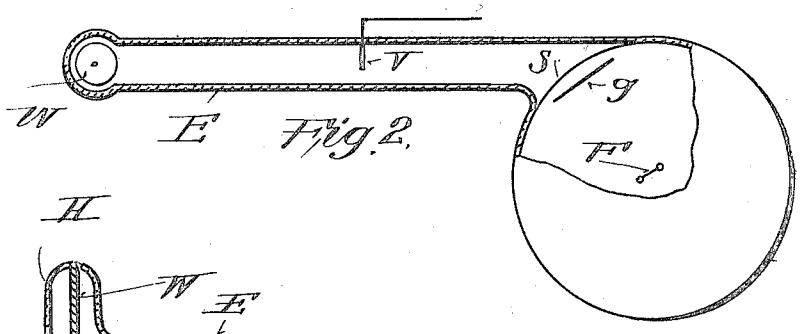



Fig. 2.

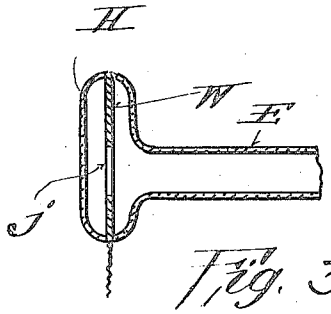



Fig. 3.

INVENTOR

Lee de Forest

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LIGHT CONTROLLING MEANS.

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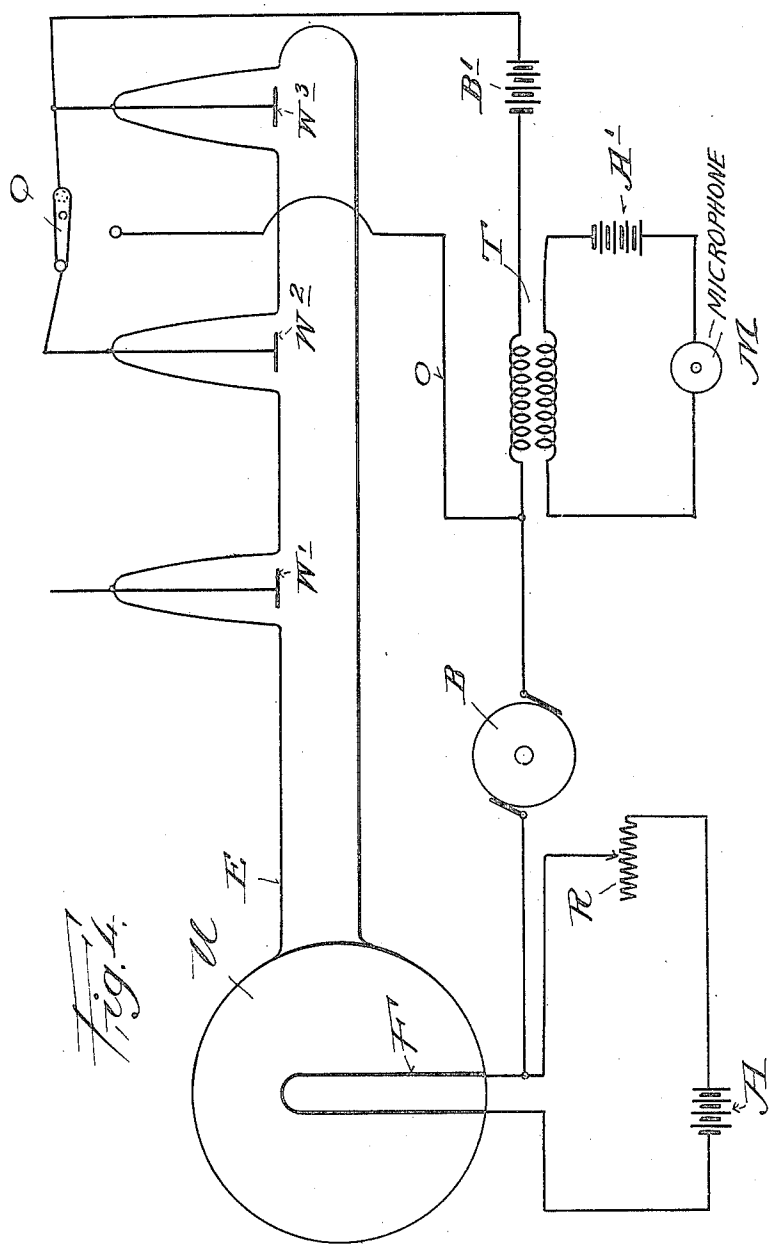



Fig. 4.

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# UNITED STATES PATENT OFFICE.

LEE DE FOREST, OF NEW YORK, N. Y.

## LIGHT-CONTROLLING MEANS.

Application filed March 16, 1921. Serial No. 452,800.

*To all whom it may concern:*

Be it known that I, LEE DE FOREST, a citizen of the United States, residing at New York, in the county and State of New York, have made a certain new and useful Invention in Light-Controlling Means, of which the following is a specification.

This invention relates to means for controlling light by and in accordance with sound waves or other type of signals.

The object of the invention is to provide means which are simple and highly efficient for obtaining exceedingly large light fluctuations by and in accordance with sound waves or other type of signals.

A further object of the invention is to provide a device which may act as a source of light, and which is extremely sensitive to sound waves, or, in other words, the light from which will vary greatly in accordance with relatively small current variations in the circuits connected therewith.

Further objects of the invention will appear more fully hereinafter.

The invention consists substantially in the construction, combination, location and relative arrangement of parts, all as will be more fully hereinafter set forth, as shown in the accompanying drawings, and finally pointed out in the appended claims.

Referring to the drawings,—

Fig. 1 is a diagrammatic view of a construction and arrangement for accomplishing the objects of and embodying my invention;

Fig. 2 is a top plan view partially in section, showing a slightly modified construction;

Fig. 3 is a sectional view showing a modified construction of anode employed in my construction;

Fig. 4 is a view similar to Fig. 1, showing a modified construction and circuit arrangement employed therewith.

The same part is designated by the same reference character wherever it occurs throughout the several views.

In accordance with my invention, I employ a gas discharge tube of the three electrode type, i. e., containing a filament and an anode and a conducting body interposed between the same, and which I will term the "luxion." In the physical structure it will be noted that the luxion is similar to the three electrode audion of my invention as disclosed in my Letters Patent No. 879,532, granted to me February 18, 1908, in that it contains three electrodes, one of which is adapted to be heated, and each of the non-heated electrodes being located at a relatively different distance from the heated electrode, and all of the electrodes being located within an exhausted or partially exhausted envelope of any suitable material, preferably of glass.

Reference letter U indicates the three electrode vacuum tube, preferably containing gas or vapor, for example, mercury vapor or the like, at preferably a low pressure. F illustrates the filament electrode led in through the envelope, and lighted as in the case of the audion from a current source A, controlled through the variable resistance rheostat R. The grid electrode *g* may be interposed between the filament F and the plate electrode to be hereinafter described, in any suitable manner, for example, it may be wound spirally around but out of contact with the filament F as shown in Fig. 1, or it may be in the form of a screen closing the entrance S of the tubular extension E of the vessel, as shown in Fig. 2. The plate or wing electrode or anode W, is preferably located at the end of the tubular extension E, and out of direct line of the axis thereof. The tubular extension E is preferably positioned tangentially of the vessel U, so that the light from the filament F may not travel longitudinally through the tubular extension E. B designates a source of current preferably, though not necessarily, a direct current, and likewise preferably of relatively high voltage, and is arranged in series with the choke coil K and the plate electrode W at one terminal, and the filament electrode F at the other terminal thereof. C designates a battery located between the grid electrode *g*, and one leg of the filament electrode F. This current source, which obviously might be of some other type than the battery, is regulated in any suitable manner, for example, by means of the standard type of potentiometer diagrammatically shown in connection therewith. T designates an iron core transformer whose secondary winding is connected in the grid filament circuit, and whose primary winding is in series with the microphone M, and a suitable source of current, for example, the current source A. V designates an auxiliary electrode either surrounding the tubular extension E, as shown

in Fig. 1, or extending into the same as shown in Fig. 2, and is connected to the filament through the choke coil K and current source B, as clearly shown by a circuit extension which is controlled by the switch Y.

I have discovered that when the filament F is lighted, the luminous gas discharge will appear between the filament F and the plate W unless too high a negative charge exists on the grid *g*. Sometimes to start this discharge it is necessary to impress a positive charge from the grid source C on the grid electrode G, or else to close the switch Y, thus putting the high positive charge from the current source B upon the auxiliary electrode V.

When the discharge is established, its intensity is extremely sensitive to the voltage impressed on the grid electrode *g*, the potential of which, either positive or negative, can be regulated by means of the potentiometer Z, connected across the current source C, as hereinabove pointed out. The light from the anode discharge through the tubular extension E will, of course, be most intense when viewed at its end. Therefore, when the light variations are employed for any of the various purposes for which it is at present employed, i. e., recording sounds on light sensitive devices such as films, or for controlling a photo electric cell, etc., I prefer to mount a lens L in alignment with the axis of the tubular extension E arranged to focus the light on the light sensitive device diagrammatically illustrated at D.

The source of light thus obtained is rich in violet and ultra violet rays, especially where hydrogen gas or mercury vapor exists in the tube, and it will be apparent that very varying results will be obtained by employing other types of gases therein. It will also be apparent that the source of light has no inertia, and its light intensity is quite directly proportional to the instantaneous potential applied to the grid or screen *g* over a large range. Hence if sound waves fall on the microphone, their effect may be exactly registered, without distortion, upon the light sensitive device D. If this device were in the form of a photograph plate or film, it would be apparent that a highly efficient photographic sound recording device is here obtained.

In Fig. 3 I have shown a slightly modified form of plate electrode W wherein the tubular extension E is provided with what I will term a foot H, across which foot the plate electrode W extends. The electrode in this instance is provided with an orifice *j* therethrough in alignment with the axis of the tubular extension E.

Many other modifications and changes in details will readily occur to those skilled in the art without departing from the spirit and scope of my invention as defined in the claims, for example, and as shown in Fig. 4, the grid electrode may be eliminated, and a filament and plate electrode alone may be employed. In this arrangement the filament is heated through the current source A at the rheostat R, and the current source B is positioned between the plate and filament electrode. To obtain varying effects, i. e., varying intensities, due to the spacial relation of the two electrodes, the tubular extension E may be provided with a plurality of plate electrodes W′, W², W³, etc., each located at a different distance from the filament electrode F. Likewise the control of the intensity of light may be effected through the microphone M included in the circuit of the battery source A′, and the primary coil of the telephone transformer T, the secondary of which is included in the plate filament circuit. It will be obvious that the terminal of the B source of current may be connected as desired to any one of the plate electrode terminals, W′, W², W³, etc., in accordance with the effect desired, or an operating condition more suitable for the work to be done.

Likewise further modifications may readily suggest themselves to those skilled in the art, for example, an auxiliary current source may be included in the plate filament circuit as illustrated in B′, with a circuit lead O tapped into the line between the two sources of potential B and B′, which lead terminates in the switch Q, adapted to place in operative relation to the rest of the system, one two or more plate electrodes W, as desired. In the arrangement shown it will be noted that the electrodes W², W³, are arranged in parallel relative to each other, and supplied with potential from both current sources B and B′. When the switch Q, however, is operated to complete the circuit of the lead O, then the current source B supplies the plate electrode W² with potential, and the auxiliary current source B′ supplies the plate electrode W³ with potential, and I have found that with such an arrangement, an extremely sensitive control of the intensity of the light within the tubular extension E of the discharge tube is thus obtained. It will, therefore, be apparent that many other modifications and changes in details will readily occur to those skilled in the art in view of the foregoing disclosures.

Having now set forth the objects and nature of my invention, and having shown and described structures embodying my invention and the principles thereof, what I claim as new and useful and of my own invention, and desire to secure by Letters Patent is:

1. A thermionic device comprising a vessel having associated therewith hot and cold

electrodes, means for heating said hot electrodes, and means for impressing an electromotive force on the space between said electrodes, to establish a relatively intensive light extending between said electrodes, and means for varying the intensity of light thus established by and in accordance with sound waves locally applied.

2. A thermionic device comprising a vessel having associated therewith hot and cold electrodes, means for heating said hot electrode to incandescence, and means for impressing a local sound controlled electromotive force on the space between said electrodes to establish a light extending between said electrodes of relatively greater intensity than that emanating from said hot electrode.

3. A thermionic device comprising a vessel having associated therewith hot and cold electrodes, means for heating said hot electrode to incandescence, means for impressing an electromotive force on the space between said electrodes to establish a light extending between said electrodes of relatively greater intensity than that emanating from said hot electrode, and means for varying the intensity of light thus established by and in accordance with sound waves locally applied.

4. A thermionic device comprising a vessel having associated therewith a filament electrode and an anode, means for supplying current to said filament, and means for impressing a local sound controlled electromotive force on the space between said filament and anode to establish a light between said filament and anode of relatively greater intensity than that emanating from said hot electrode.

5. A thermionic device comprising a vessel having associated therewith a filament electrode and an anode, means for supplying current to said filament, and means for impressing an electromotive force on the space between said filament and anode to establish a light between said filament and anode of relatively greater intensity than that emanating from said hot electrode, and means for varying the intensity of light thus established by and in accordance with sound waves locally applied.

6. A source of light comprising a vessel comprising a hot and a plurality of cold electrodes, means for establishing the light source between said hot electrode and one of said cold electrodes, and means for controlling the intensity of light by and in accordance with local sound controlled potential variations applied to another cold electrode.

7. A source of light comprising a vessel having associated therewith a cathode and anode and a control electrode positioned between said cathode and anode, means for establishing the light source between said cathode and anode, and means for controlling the intensity of light by and in accordance with sound controlled potential variations locally applied to said control electrode.

8. A source of light comprising a vessel comprising a hot and a plurality of cold electrodes, means for establishing the light source between said hot electrode and one of said cold electrodes, and means for controlling the intensity of light by and in accordance with potential variations applied to another cold electrode, and local sound controlled means for applying potential variations upon said last named cold electrode.

9. A source of light comprising a vessel having associated therewith a cathode and anode and a control electrode positioned between said cathode and anode, means for establishing the light source between said cathode and anode, and means for controlling the intensity of light by and in accordance with potential variations applied to said control electrode, and local sound controlled means for applying potential variations upon said control electrode.

10. A source of light comprising a vessel having associated therewith a cathode and anode and a control electrode positioned between said cathode and anode, means for establishing the light source between said cathode and anode, and means for controlling the intensity of light by and in accordance with sound waves locally applied.

11. A source of light comprising a vessel comprising a hot and a plurality of cold electrodes, means for establishing the light source between said hot electrode and one of said cold electrodes, and means for controlling the intensity of light by and in accordance with locally applied sound waves.

12. A source of light comprising a vessel having associated therewith a filament electrode, an anode and a control electrode positioned between said filament and anode, means for establishing a light source between said filament and anode, and means for controlling the intensity of the light by and in accordance with locally applied sound waves.

13. A source of light comprising a vessel having associated therewith a filament electrode, an anode and a control electrode positioned between said filament and anode, means for establishing a light source between said filament and anode, and means for controlling the intensity of the light by and in accordance with potential variations applied to said control electrode, and local sound controlled means for applying potential variations upon said control electrode.

14. A source of light comprising a vessel containing a filament electrode therein, and an extension for said vessel containing an

anode therein, said anode being separated from said filament by a space greater than the largest diameter of said vessel, means for heating said filament, and means for establishing a light between said filament and anode, a sound controlled means for varying the intensity of said light.

15. A source of light comprising a vessel containing a filament electrode therein, and an extension for said vessel containing an anode therein, the axis of said extension being out of alignment with said filament electrode, means for heating said filament, and means for establishing a light between said filament and anode a sound controlled means for varying the intensity of said light.

16. A source of light comprising a vessel containing a filament electrode therein, and an extension for said vessel containing an anode therein, the axis of said extension being out of alignment with said filament electrode, means for heating said filament, and means for establishing a light between said filament and anode, said anode being likewise out of alignment with the axis of said extension to permit the light source to be observed axially relative to said extension, a sound controlled means for varying the intensity of said light.

17. A device of the character set forth, comprising a vessel having associated therewith a plurality of electrodes, means for impressing electromotive force on the space between said electrodes to establish a relatively intensified light extending between said electrodes, and means for varying the intensity of light thus established by and in accordance with sound waves locally applied thereto.

18. A device of the character set forth, comprising a vessel having associated therewith a plurality of electrodes, an extension for said vessel having associated at the approximate end thereof one of said electrodes, means for thereby establishing a light between said electrodes, and locally applied sound controlled means for varying the intensity of said light.

19. A device of the character set forth, comprising a vessel having associated therewith a plurality of electrodes, said vessel having an extension having associated therewith one of said electrodes, the axis of said extension being out of alignment with the axis of said vessel, means for establishing a light between said electrodes, and locally applied sound controlled means for varying the intensity of said light.

20. A device of the character set forth comprising a vessel having associated therewith a plurality of electrodes, a source of current for impressing electromotive force on the space between said electrodes to establish a relatively intensified light extending between said electrodes, a transformer coil connected in series with said source of current, and a sound controlled device locally associated with said transformer for varying the intensity of said light.

In testimony whereof I have hereunto set my hand on this 11" day of March, A. D., 1921.

LEE DE FOREST.