No. 843,534. PATENTED FEB. 5, 1907.

P. C. HEWITT.

METHOD OF PRODUCING ELECTRIC LIGHT.

APPLICATION FILED SEPT. 28, 1900.

2 SHEETS—SHEET 1.

Fig.1

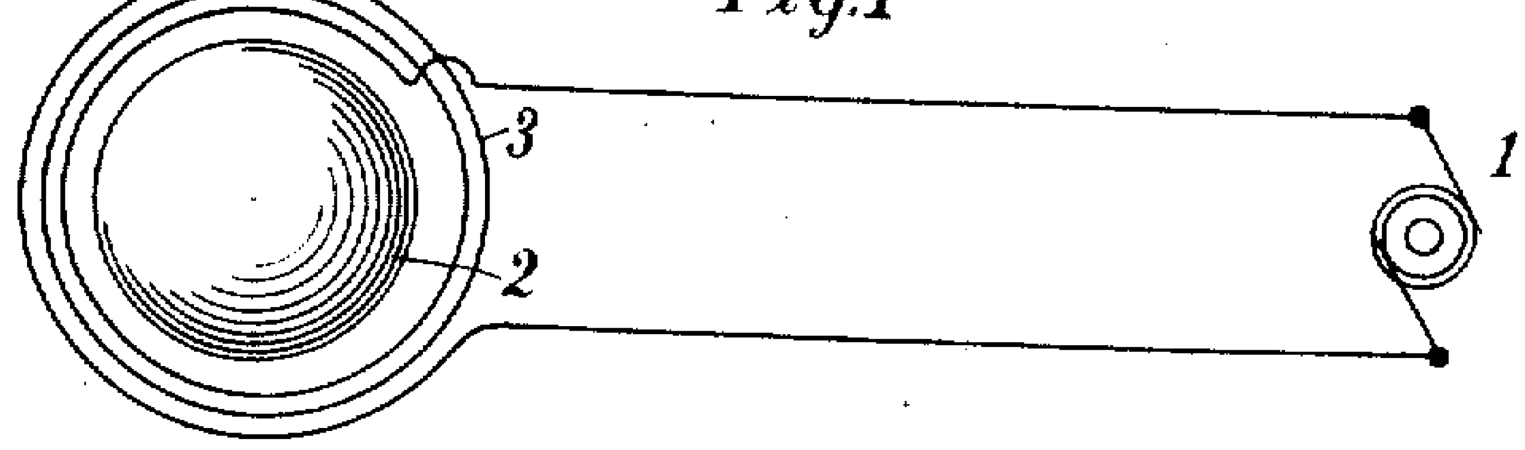


Fig.2

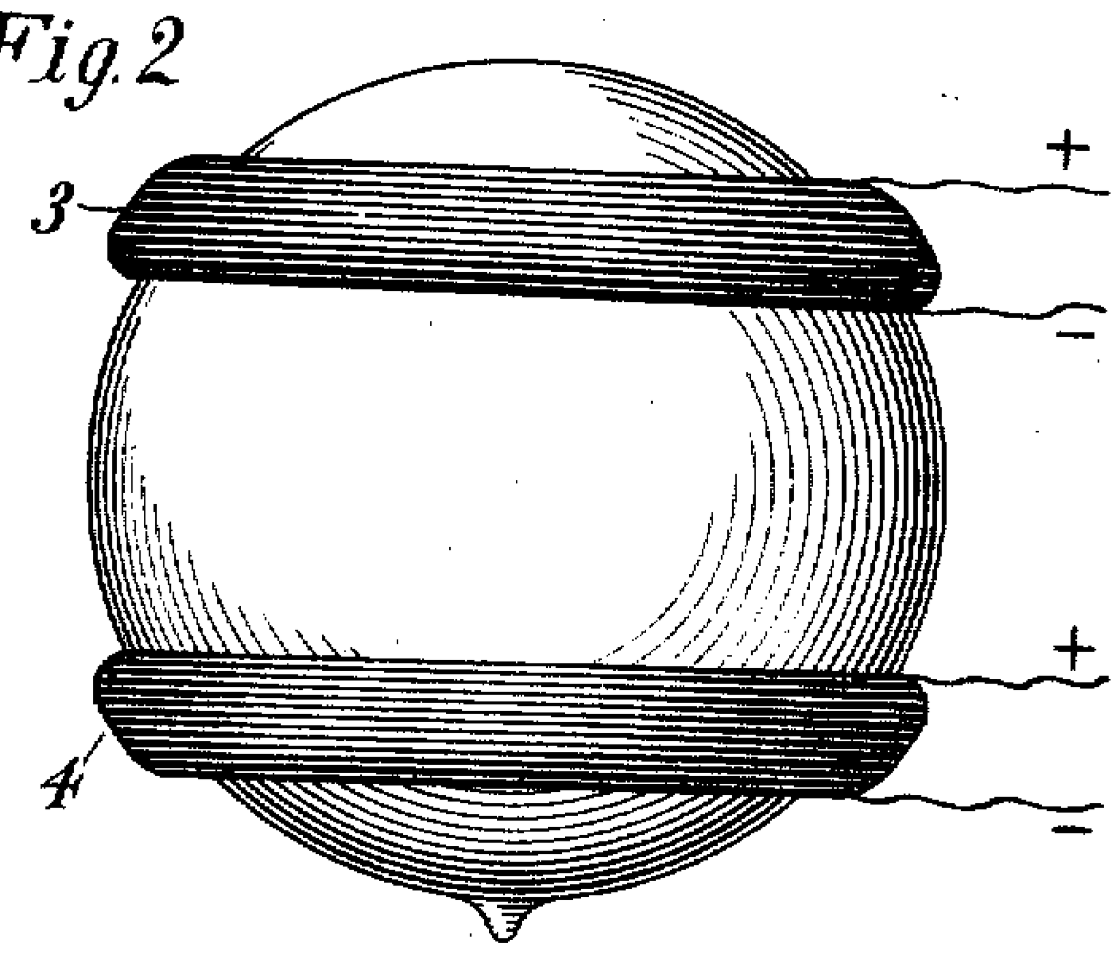


Fig.3

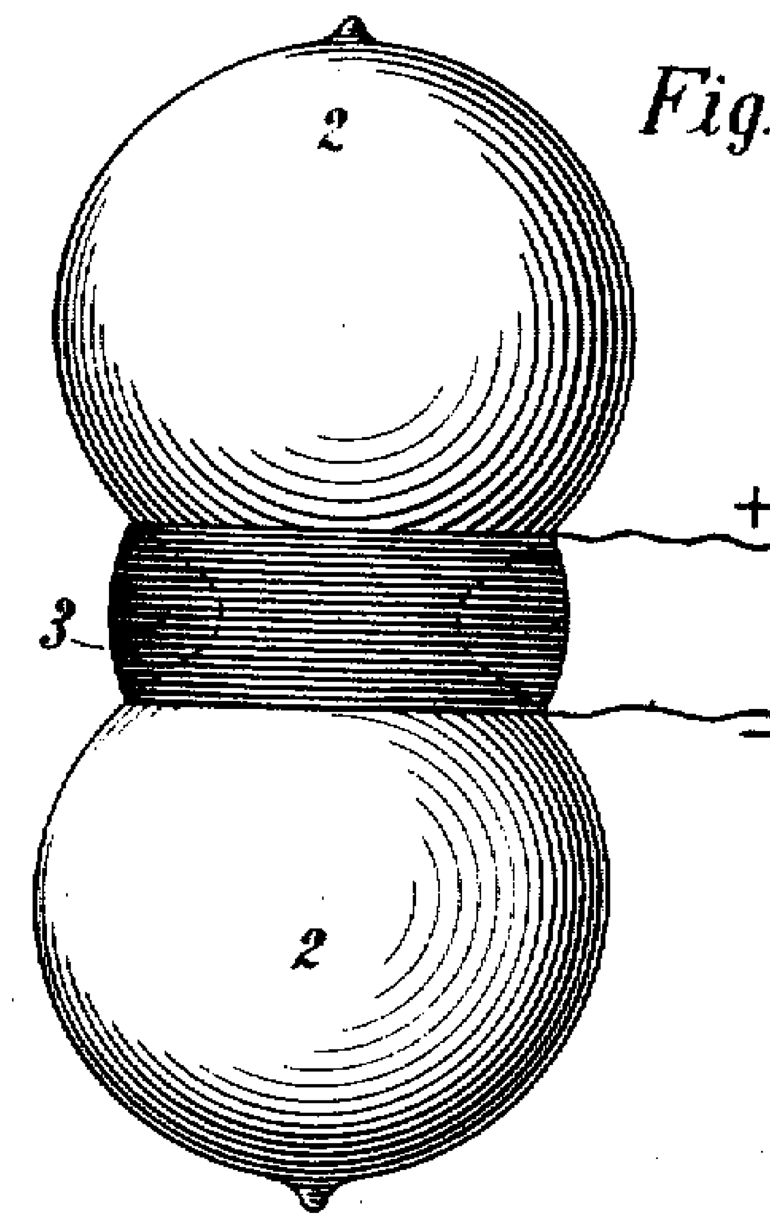


Fig.4

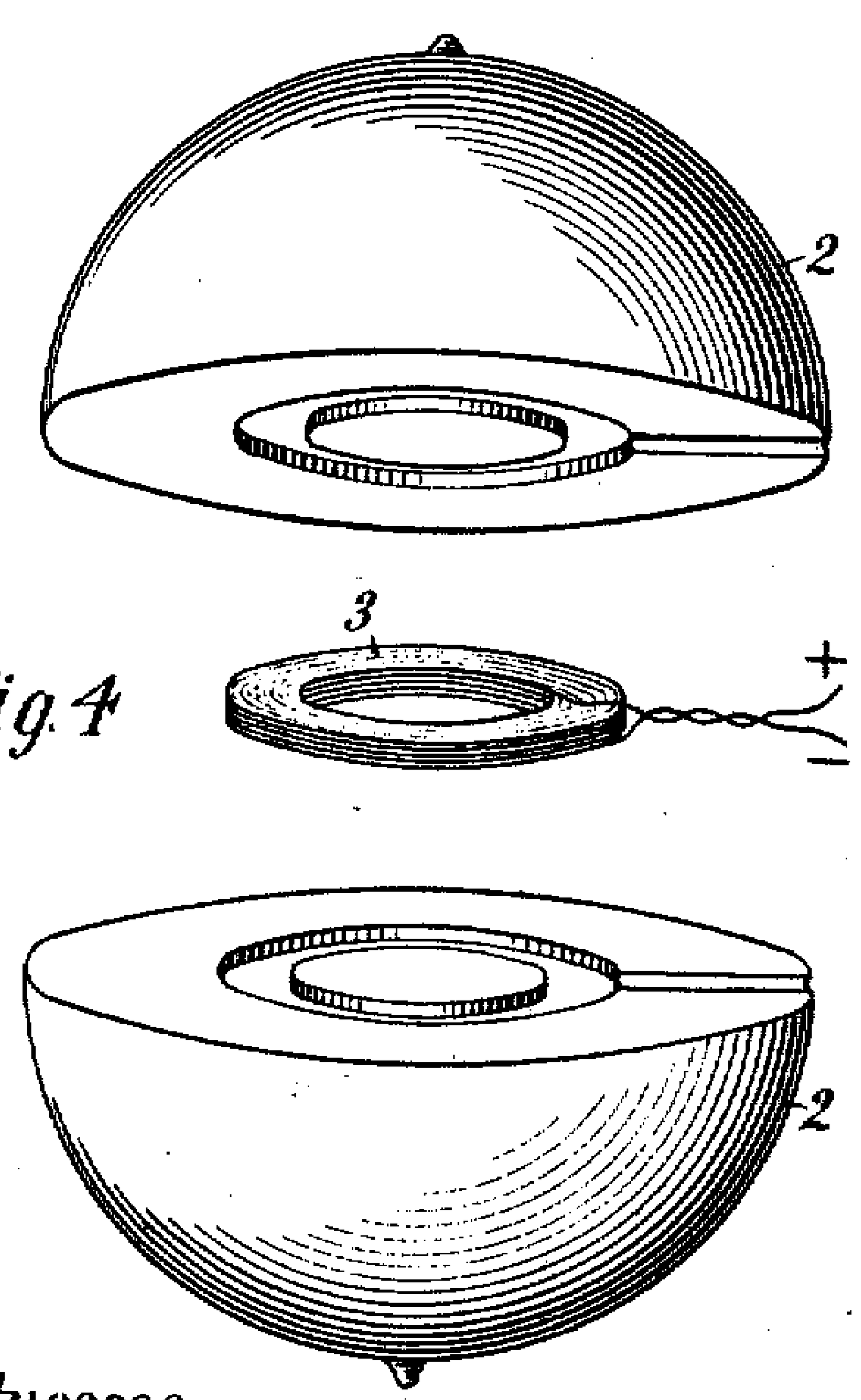
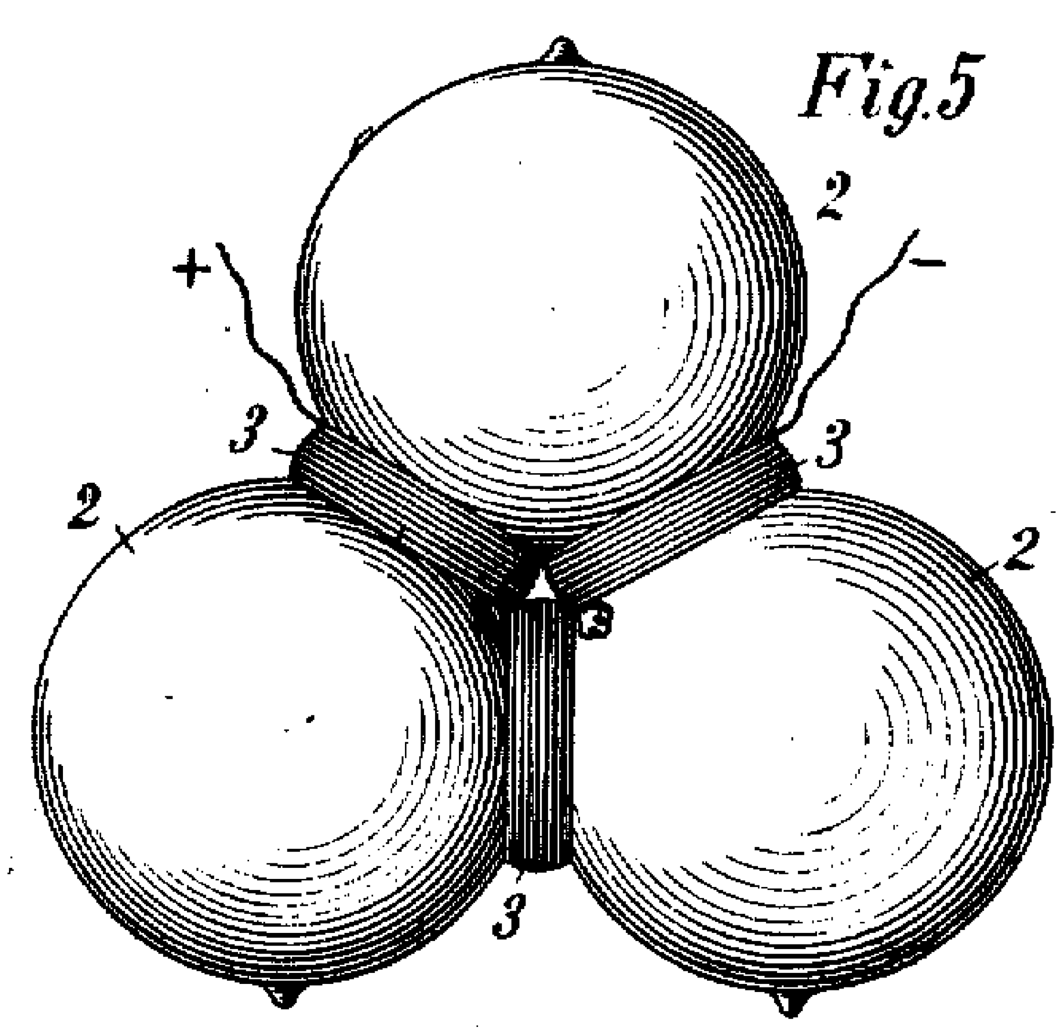


Fig.5



Witnesses:

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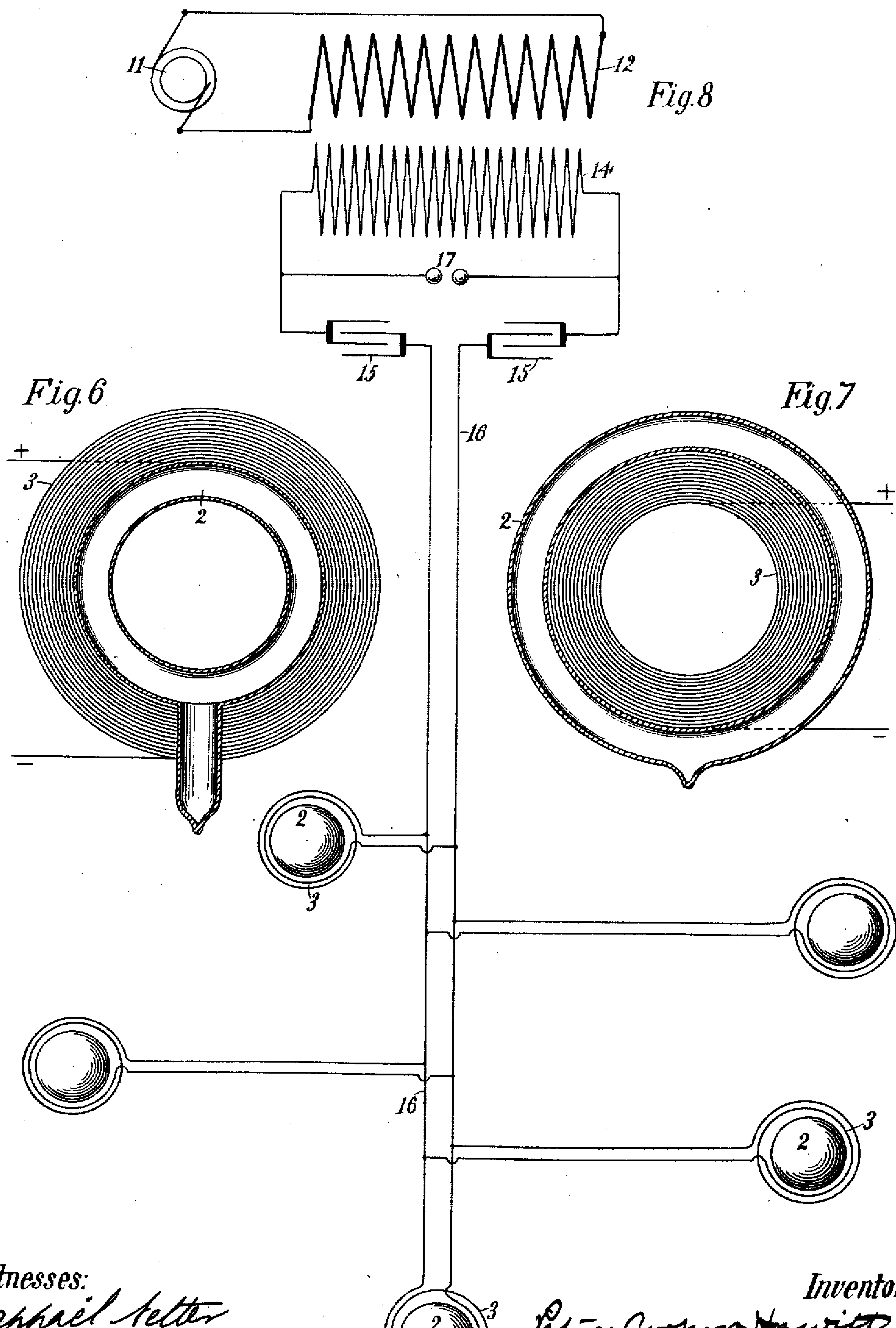
2 SHEETS—SHEET 2.



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UNITED STATES PATENT OFFICE.

PETER COOPER HEWITT, OF NEW YORK, N. Y., ASSIGNOR, BY MESNE ASSIGNMENTS, TO COOPER HEWITT ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

METHOD OF PRODUCING ELECTRIC LIGHT.

No. 843,534. Specification of Letters Patent. Patented Feb. 5, 1907.

Original application filed April 18, 1900, Serial No. 13,291. Divided and this application filed September 28, 1900. Serial No. 31,346.

To all whom it may concern:

Be it known that I, PETER COOPER HEWITT, a citizen of the United States, and a resident of New York, in the county of New York and State of New York, have invented a certain new and useful Improvement in Methods of Producing Electric Light, of which the following is a specification.

The existing state of the art of lighting by electricity presents various forms of lamps and methods of lighting. In my lamp the actual light-generating current is induced in the medium where the light is generated, the current being what is known as a "secondary" current.

The present invention relates to a method of lighting by means of my improved lamp, the apparatus itself and the system under which it operates being claimed in a separate application, filed April 18, 1900, Serial No. 13,291, of which this application is a division.

Broadly, it relates to a method of lighting which shall yield a practical light without any conductor leading into the lamp, thus making it possible to dispense with any break or joint in the electric circuit. This I accomplish by using vapor or gases of proper character and under proper conditions as the medium for transforming the electric energy into light, the energy being caused to be present in the vapor or gases which serve as a conductor by induction. In this way I dispense with conductors leading into the contained vapor or gas through the walls of the container.

It may be generally stated that a coil of wire traversed by a varying current of electricity is surrounded by a varying magnetic field consisting of so-called "magnetic lines of force." The field of force thus established, however, varies in proportion with the variations of the current, and if a closed circuit—such, for instance, as a coil of wire—be properly placed within this varying field of force there will be induced in it a current corresponding to the variations in the field of force. A device of this character is usually termed an "induction-coil" or "transformer." If there be substituted for the secondary coil of the transformer a closed circuit of some vapor or gas of the proper character and under the proper conditions, it will act as a conductor, and the energy of such current will be induced in it if the rate of change is suitable. The energy of such current will manifest itself in the form of light and heat if sufficient lines of force are cut by the vapor to overcome its tendency to resist becoming a conductor.

The induced current in the lamp and its voltage depend upon the general laws of induction—namely, the relation of the turns in the primary to those in the secondary and the rate of change of the pulsations or variations in the actuating or primary current or, in other words, the rate at which the magnetic lines due to the primary current are cut by the secondary circuit. This rate is the measure of the electromotive force given to the secondary circuit.

In the form of lamp which I have devised it is practicable to employ for the secondary circuit a simple closed circuit of vapor having effectively one turn in connection with a multiple-turn primary giving a suitable ratio of step-down transformation.

For the purpose of developing an electromotive force in the secondary sufficient to place it in a state where it will become readily conductive—that is, a true vapor-conductor of low resistance—I make use of a current of such quantity and rate of variation in a primary of such multiplicity of turns and such interlinkage as will induce in one turn of a secondary an electromotive force which shall be sufficient to break down the tendency of the vapor to resist becoming a conductor, notwithstanding the decrease of electromotive force which must result from the use of such multiple-turn primary as will give the required interlinkage with the said vapor secondary.

The vapor which I find most convenient in use is that obtained from mercury, because of its low resistance; but other materials may be used, the use of any vapor being dependent only upon the requirement that there shall be induced in it a voltage sufficient to overcome its resistance. Certain impurities or vapors added to the vapors which are selected for forming the secondary or light-emitting circuit exercise such a reluctance to the passage of the electric current that it is almost impossible with the most rapid variation of current to induce a secondary current in the lamp when they are present. Such vapors as will be obtained from water and some oxygen compounds seem to have this state of non-conductivity in a marked degree. Also the vapors usually present in a globe until it has been exhausted, heated, and the current induced in it, which current liberates more non-conducting vapors, would seem to render the desired state of conductivity almost impossible to attain; but by properly preparing the lamp and supplying the globe with the conducting-vapor freed from the objectionable ones a condition is reached where a practical and enduring lamp is obtained. The conducting-vapor when in its conducting state, being a conductor requiring a rate of change in the primary that will induce in a secondary of one turn an electromotive force of, say, from three to fifty volts per inch in case the secondary is, say, three inches in diameter, the inducing-current need not be over a few hundred volts when the current is passing in the vapor, the voltage depending upon the material of the vapor, its density, and other conditions.

The amount of light emitted by the gas readily shows at what time during the process of manufacture the lamp is completed.

I am aware that others have proposed certain lamps claimed to be induction-lamps having a luminous band induced therein; but in none has any considerable amount of light been produced.

My lamp yields a large quantity of light and possesses other characteristics which clearly distinguish it from the faint luminosity of the electrostatic effect produced in the lamps above alluded to. The difference is also at once apparent in the source of current.

In the operation of the lamp the voltage required to cause current to pass in the ring or body of vapor appears to decrease suddenly after a suitable degree of induction is arrived at, indicating that some radical change of characteristics takes place. The resistance tends to vary inversely with the current passed, as shown by other experiments with vapor conductivities, where the vapor secondary is included in inductive relation to an oscillatory current flowing in an oscillatory circuit. The oscillatory effects are practically annulled as the vapor secondary, when this condition is arrived at, will absorb in the first oscillation practically all of the energy that is present in the oscillatory circuit. This may be demonstrated by means of a tertiary circuit of a single turn of wire, including an incandescent lamp, which when the vapor secondary is not present will become luminous and carry current; but when a vapor secondary having the characteristics of my lamp is introduced in inductive relation to the primary it will absorb the energy delivered to the primary, and thus rob the tertiary circuit, so that the incandescent lamp will no longer be illuminated and practically no current will flow in the tertiary circuit.

The invention will be described more in detail in connection with the accompanying drawings.

Figure 1 is a diagrammatic view of one form of my lamp connected with a generator. Fig. 2 is an elevation of one form of my lamp, using two primary coils. Figs. 3, 4, 5, 6, and 7 are views showing other forms of lamp. Fig. 8 is a diagrammatic view of several lamps and a form of generator in circuit therewith.

Referring to the drawings, 1 is any suitable source of rapidly-varying currents, and 2 is a closed container, the shape of which may be varied to suit the circumstances. Within the vessel 2 there is placed the desired vapor or gas of suitable density to be rendered light-radiant or light-emitting. A coil 3 of insulated wire of the proper number of turns constitutes the primary coil of the transformer, the vapor or gas within the vessel being the secondary circuit. The coil 3 is connected with the energizing-coil 1. On the passage of a current of the proper character through the coil 3 a current is induced in the vapor. Immediately the vessel becomes brightly luminous. A change in position of the primary coil causes a corresponding change in the position of the luminosity. By increasing the amount of energy imparted from the primary source practically all of the vapor in the lamp may be made to act as a secondary and to give the lamp a very intense brightness. The addition of a second coil 4 on the globe of the vessel 2 (see Fig. 2) causes an increase of luminosity.

In Fig. 3 a form of lamp is shown in which one bulb 2 is made with a narrow neck and a coil 3 encircles the narrow portion. The operation is essentially the same as that described with reference to Fig. 1.

In Fig. 4 a form is shown consisting of two hemispherical bulbs 2 2, having suitable depressions in their faces for receiving the coil 3. The bulbs are then placed together with the coil 3 between them, and currents through this coil act upon the contents of both bulbs.

In Fig. 5 a modification is shown in which three bulbs 2 2 2 are shown arranged in close proximity to each other with coils 3 3 3 placed between them. These three coils may be connected in series or in parallel, as desired.

As already stated, the vapor which I find very convenient for use is that of mercury. This vapor offers a low resistance and produces a very intense white light. Other gases or vapors may, however, be used, care being taken to select such as will receive current under the influence of such a voltage as may be induced therein, and the light emitted thereby will correspond to the spectrum of that gas or vapor.

The operation of the lamp depends upon the possibility of obtaining a current of suitable rate of variation. I have obtained excellent results by the use of the discharge-currents obtained from condensers; but a properly-constructed mechanical generator would produce the necessary current.

In Fig. 8 I have represented diagrammatically one form of apparatus giving a rapidly-varying current suitable for use to operate my lamp. This generator is indicated at 11 and produced an alternating current of, say, one hundred and twenty-five to three hundred periods per second and of a voltage of, say, from fifty to one hundred volts. The generator supplies the primary coil 12 of a transformer, the secondary coil 14 delivering an induced current of, say, six thousand volts. This induced current is delivered to condensers 15 of suitable capacity, which may be arranged to be discharged through the line 16. I usually prefer, however, to use two condensers 15 15, as shown, using the current induced between them through the line 16. The discharge-gaps 17 limit the charge of the condensers and serve to discharge them. Other forms of discharge devices may be employed—as, for instance, the well-known vapor-discharge devices disclosed in many of my early patents and applications. Each time the condensers are charged and discharged the current induced between them will flow back and forth through the line 16. One of the glass vessels 2 being placed in the field of the coil 3 will act as a secondary, tapping off the amount of current that the lamp is constructed to take. The coil 3 thus becomes the primary and the vapor in the vessel the secondary of my vapor transformer or lamp. With a pressure of six thousand volts and a bulb six inches in diameter a coil 3 of fifteen turns will serve to illuminate the bulb. With bulbs having other characteristics the best number of turns may be determined by trial.

In manufacturing my lamp I usually proceed as follows: The lamp is connected with an exhaust-pump to remove the water and any vapors that may be contained in the glass of the bulb, the bulb being heated during the process of exhausting. I then introduce or generate in the lamp the vapor upon which I desire to operate and which is to act as the secondary, still retaining the connection with the exhaust-pump, usually introducing more of the vapor than it is intended shall remain in the lamp when completed. While still connected with the exhaust-pump I place a coil, such as the primary 3, Fig. 2, in such position that its field may include the bulb and its inclosed vapor. There is then passed through this primary coil a rapidly-varying current, and the effect upon the vapor in the bulb is carefully noted. After the foreign and objectionable gases have been pumped out and the gas or vapor which is to be illuminated has reached the proper density the bulb receives the desired amount of current and becomes brilliant. It is then sealed off from the pump and is finished.

The light produced by this lamp is an intensely luminous light in distinction from the foggy or hazy condition which may be produced by means of electrostatic effect. In the producton of my lamps this foggy or hazy effect is produced during their preparation, usually during the period of exhaustion before the density of the ultimate conducting vapor has been regulated and always in highly-rarified gases with exceedingly rapid rate of variaton of the current obtained from the use of small condensers and very high voltage. This electrostatic effect usually appears striated radially in a band in the tube, the striations appearing like the open spaces in an ordinary carriage-wheel.

The completed apparatus acts like an ordinary transformer, the primary in this case being the coil 3 and the secondary being the part 2 with its contained vapor or, more strictly, the contained vapor itself. Unless current is drawn off by the secondary the primary, as in an ordinary transformer, chokes back the current in the line and prevents the passage of current through the primary coil.

The invention claimed is—

1. The method of producing light through the medium of an inclosed gas or vapor, which consists in inclosing in a suitable chamber, a gas or vapor of such density as to be capable of becoming the secondary of an inductive circuit, and subjecting the gas or vapor to the influence of such inductive circuit, the said circuit being of such a character as to induce in the vapor-circuit currents of sufficient quantity to cause the gas or vapor to attain its state of maximum conductivity.

2. The method of producing light from the energy of a varying electric current, which consists in opposing to the flow of the current through a circuit, a counter electromotive force approximately equal to the applied electromotive force, and subjecting an inclosed gas or vapor to the inductive influence of said circuit, thereby modifying the counter electromotive force in proportion to the energy consumed by the current traversing the gas or vapor.

3. The method of operating a vapor-lamp by electromagnetic induction, which method consists in subjecting said lamp to a rapidly-varying magnetic field of such rapidity of variation and of such total energy as will cause the inclosed vapor to become a low-resistance vapor-conductor.

4. The method of operating a vapor device which method consists in transferring to the vapor by electromagnetic induction, suffi-

cient electric current to cause said vapor to pass its critical breaking-down point as a dielectric and to become a low-resistance vapor-conductor.

5. The method of operating a vapor device which method consists in transferring to the vapor by electromagnetic induction, sufficient electric current to cause said vapor to pass its critical breaking-down point as a dielectric and to become a conducting secondary of a resistance so low as to absorb substantially all the energy flowing in the primary circuit.

6. The method of increasing the efficiency of a high-frequency transformer, having a secondary composed of an inclosed vapor, normally non-conducting but adapted to become a low-resistance vapor-conductor acting as a single-turn secondary, which method consists in adjusting the ratio of the step-down transformation to the characteristic and conditions of the inclosed vapor constituting the secondary.

7. The method of increasing the efficiency of a transformer having a secondary composed of a material normally non-conducting but adapted to become a low-resistance conductor, which method consists in adjusting the ratio of step-down transformation to the characteristics and conditions of the material constituting the secondary, by adjusting the number of turns of a multiple-turn primary coil.

8. The method of increasing the quantity of current flowing in the secondary of a step-down transformer comprising a primary circuit and a single-turn secondary consisting of an inclosed vapor normally non-conducting but capable of becoming a conductor of low resistance, which method consists in predetermining the number of turns of the primary to decrease the voltage and increase the quantity of the said current to a ratio most suitable to the characteristics and conditions of said inclosed vapor.

9. The method of increasing the quantity of current flowing in the secondary of a step-down transformer comprising a primary circuit and a secondary consisting of a material normally non-conducting but capable of becoming a conductor of negative temperature coefficient and low resistance, which method consists in predetermining the number of turns of the primary to secure the interlinkage and quantity current with respect to the characteristics and conditions of said material in such manner as to cause said secondary to reach the condition of a low-resistance conductor.

10. The method of breaking down a dielectric consisting of a body of vapor, which method consists in subjecting the vapor to a rapidly-varying elecromagnetic field of which the energy and interlinkage is predetermined to the reluctance and current-carrying capacity of said vapor.

11. The method of preventing oscillations in an excited oscillatory circuit which method consists in absorbing the energy thereof in a vapor secondary of such volume, density and conductivity and so interlinked with the primary circuit as to absorb substantially all of the energy of the latter within the time of the natural period of a single oscillation thereof.

12. In the art of producing light by electromagnetic induction in an inclosed vapor, the method of impressing large amounts of energy upon said vapor, which method consists in causing rapidly-varying currents to traverse the multiplicity of turns of a primary coil in inductive relation to said vapor and predetermining or adjusting the quantity of the current-supply in accordance with the number of turns of the primary and the characteristics and conditions of the vapor.

13. In the art of operating vapor-lamps by electromagnetic induction, the method which consists in constituting the vapor of said lamp the secondary of a step-down transformer and compensating for the resulting reduction of the voltage impressed upon the vapor by increasing the quantity of the current flux in the primary coil.

14. The method of operating a vapor-lamp which method consists in transferring to the vapor by electromagnetic induction, sufficient current to cause said vapor to pass its critical breaking-down point as a dielectric to pass the condition of high resistance and to become a low-resistance vapor-conductor.

Signed at New York, in the county of New York and State of New York this 24th day of September, A. D. 1900.

PETER COOPER HEWITT.

Witnesses:

WM. H. CAPEL,

WILLIAM L. HEWSON.