No. 685,728. Patented Oct. 29, 1901.

W. NERNST.

ELECTRIC GLOW LAMP.

(Application filed Apr. 10, 1901.)

(No Model.)

Fig. 1.

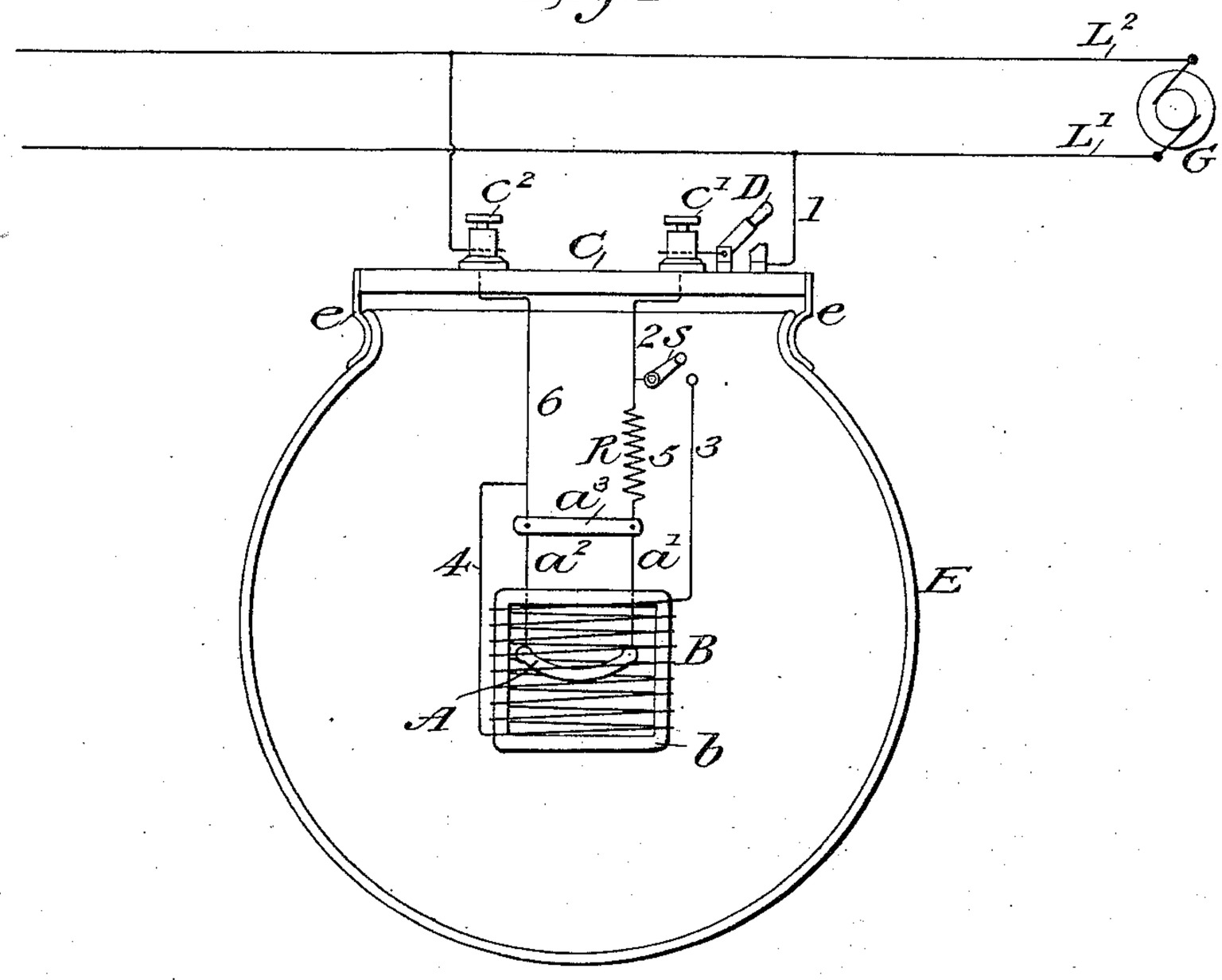
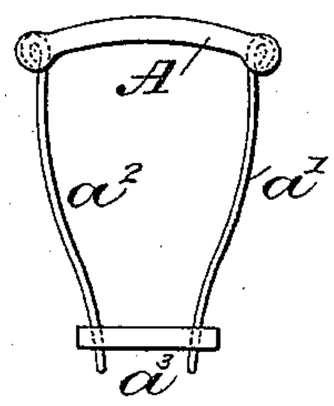


Fig. 2.



Witnesses:

J. H. Jones

H. B. Tenney

Inventor:

Walther Nernst,

by Charles A. Perry.

Atty.

UNITED STATES PATENT OFFICE.

WALTHER NERNST, OF GÖTTINGEN, GERMANY, ASSIGNOR TO GEORGE WESTINGHOUSE, OF PITTSBURG, PENNSYLVANIA.

ELECTRIC GLOW-LAMP.

SPECIFICATION forming part of Letters Patent No. 685,728, dated October 29, 1901.

Original application filed April 28, 1898, Serial No. 679,081. Divided and application filed May 29, 1899, Serial No. 718,624. Again divided and this application filed April 10, 1901. Serial No. 55,222. (No model.)

To all whom it may concern:

Be it known that I, WALTHER NERNST, a subject of the Emperor of Germany, and a resident of Göttingen, Germany, have invented certain new and useful Improvements in Electric Glow-Lamps, (division of an application filed by me April 28, 1898, Serial No. 679,081,) of which the following is a specification.

My invention relates to the class of electric-lighting devices known as "incandescent electric lamps," but differs fundamentally from the incandescent lamps heretofore used and involves certain peculiar features and characteristics which justify its classification as a distinct and novel species.

Heretofore all practical incandescent electric lamps have comprised a filament of conducting material, usually, if not always, of carbon, contained within an inclosing chamber from which the air is exhausted. The fact that the filaments heretofore employed will oxidize when heated in the open air has necessitated inclosing them in vacuum-chambers.

Various refractory materials comprising certain oxids, sulfids, silicates, and other salt-like compositions of metals are specially qualified to emit light when heated to a high temperature. It has been proposed to utilize the light-emitting qualities of such materials by maintaining them in a state of incandescence by a gas-flame, as illustrated by the well-known "Welsbach burner," for instance. When the light-emitting qualities of these refractory materials were to be used in connection with electric lighting at ordinary voltages, it has heretofore been considered necessary to either maintain them in an incandescent state by placing them in proximity to conductors heated by electric currents or to coat them or add to them or in some way combine with them some good conducting material, such as a metal or carbon, which should afford a conducting-path for the current. For example, it has been proposed to impregnate or coat conductors—such, for instance, as platinum, iridium, or carbon—with a refractory material—such, for instance, as calcium or zirconia—and to use the heat developed in the conducting material for maintaining the refractory material in an incandescent light-emitting condition. Such combinations, however, have been found to be inoperative for any useful purpose. The platinum or carbon or other conducting material either itself melts or disintegrates or causes the refractory material to crack off or disintegrate.

I have discovered that certain refractory salt-like combinations, particularly oxids usually classed as the "rare earths," which are at ordinary temperatures "non-conductors of electricity," as that term is usually employed, will when raised to the high temperature of incandescence become sufficiently good conductors to permit the passage of an electric current under moderate differences of potential and may be maintained sufficiently heated to retain their thus acquired conducting qualities by the passage of the electric current therethrough. These materials when so traversed by electric currents not only emit more light under the influence of a given amount of electrical energy than the ordinary incandescent lamp, but they also resist decomposition and disintegration even in the open air, and therefore a lamp constructed in accordance with my invention does not require a vacuum-chamber, though a vacuum-chamber may be used in certain cases, if desired.

The general characteristics of the light-giving portion of my lamp are so widely different from those of the ordinary incandescent electric lamp that to term it a "filament" would be not only inappropriate, but to a certain extent misleading. The light is emitted therefrom without combustion or material disintegration, even when exposed to the air, and being translucent it emits light from its interior and from its surface, and I have given the name "glower" to the light-giving portion and "glow-lamp" to the lamp itself as being properly applicable.

The materials which I have discovered to possess the qualities above referred to may be classed under the general term of "dry elec-

trolytes" or "dry conductors of the second class." By the expression "conductors of the second class" I refer to those which when in a conducting condition conduct current by electrolytic action.

Prominent among the materials with which I have obtained excellent results may be mentioned oxid of magnesium, or magnesia, and oxid of zirconium, or zirconia; also, the oxids of yttrium, cerium, thorium, and the like. These materials when in a dry state and at normal temperatures are practically insulators or non-conductors; but when glowers made from them are heated to a state of incandescence they acquire conducting qualities to such an extent that electricity may be caused to pass through them at ordinary low pressures in sufficient quantities to keep them in a state of incandescence even after the means employed for imparting the original starting-heat is withdrawn. Instead of using these materials individually or alone for forming the glower, two or more of them may be mixed or combined in varying proportions with advantageous results. Glowers made from a proper mixture of certain of the materials will pass into the conducting state at a lower initial or starting temperature than will a glower made from one of the materials alone and will maintain under the passage of the electric current a luminous condition without deterioration better and for a longer time than will any single one of such materials. It is not therefore the mere mixture of such materials that I prescribe, but the utilization of such mixtures on account of their superior properties when brought to and maintained in a luminous condition. These materials, even when in their best operating conducting condition, have a specific resistance so great with reference to that of carbon that a glower to be used with a given voltage may be much shorter and thicker than the carbon filament of an ordinary incandescent lamp. For instance, a practical glower of, say, one-fiftieth of an inch in diameter and one-half an inch in length may be made which when heated to a low incandescence will become a sufficiently good conductor to be traversed under a one-hundred-volt difference of potential by a sufficient current to bring it to and maintain it at a state of high incandescence. A current of, say, four-tenths of an ampere or thereabout will accomplish this result. As the material has sufficient strength to enable it to be used in much longer lengths than that above referred to, it is possible to construct lamps adapted to be operated at very much higher voltages than is practicable with lamps using carbon filaments, a feature which may be utilized to obtain economy of transmission. This feature, in connection with the high efficiency of the lamp, renders it possible to secure either a given illumination with a much higher transmission efficiency than at present obtained or a higher illumination with the present transmission efficiency, or both the illuminating and transmission efficiencies may be materially increased.

There are numerous different proportions in which the different refractory materials adapted to the purposes of my invention may be used, and there is a very wide range for the selection of the different materials to be mixed together, and therefore I will attempt only, and it will only be necessary, to specify one or two examples. Very excellent results have been obtained from a mixture of approximately seventy per cent. of zirconia and thirty per cent. of yttria, (oxid of yttrium.) Another mixture which I have used with good advantage consists of approximately ten per cent. of zirconia, seventy per cent. of thoria, and twenty per cent. of yttria. I have also obtained excellent glowers from a mixture of about seventy per cent. of thoria and thirty per cent. of yttria. Another mixture consists of 0.5 per cent. of ceria, eighty per cent. of thoria, with 10.5 per cent. of yttria. These percentages may be widely varied, and, generally speaking, the oxids of the rare earths are well adapted for mixture in widely-varying proportions.

The process of preparing the glowers from which I have heretofore obtained the best results when two or more of the oxids are to be used together consists in thoroughly pulverizing and mixing the materials together into very intimate relations, then mixing therewith a binder of clear-starch paste, making a plastic mass which should be thoroughly worked. The water used in making the paste should be clear and preferably distilled to avoid the presence of lime, which is more volatile than the oxids of the rare earths, and therefore undesirable. The plastic mass may then be inserted in a press adapted to force the mixture through a small hole of the requisite diameter dependent upon the ultimate diameter desired for the glower, and as the material leaves the press it may be hung over a glass rod or laid upon a suitable supporting-surface and allowed to dry. The material acquires sufficient strength when dried to be conveniently handled, and it is then heated to a very high temperature in any suitable manner—for instance, in an oxyhydrogen-flame. It is desirable that as great a specific gravity as possible may be given to the material—that is to say, the smallest diameter for a given mass of a given length. Care should be taken that every part of the glower is brought to a high incandescence. Usually it is advantageous to heat the material gradually, so as to drive off the moisture and the binding material slowly, and thus lessen the liability of the surface becoming cracked. For example, it may be passed through a preliminary heat in a porcelain kiln. The eventual heating, however, should be carried to an extremely-high temperature. When the material has been thus prepared, a proper length, dependent upon the voltage and current with which it is to be used, is mounted between two suit-

able conducting-wires. The ends may advantageously be fastened mechanically in any suitable way—as, for instance, by inserting them into suitable sockets made by forming into spirals the conducting-wires, which may be of platinum or other good conducting materials which melt only at a very high temperature. The junctions of the glower with the respective wires are then built up by placing thereon, in a liquid or paste-like condition, small quantities of a cementing material and heating and drying the same in a gas-flame or otherwise. This process is repeated until a firm union is obtained between the respective ends of the glower and the wires. It is advantageous also to make the points of juncture with the wires of larger diameter than the main portion of the glower, for then the points of contact with the wire will not during the operation of the lamp be as hot as the remainder of the glower, and therefore the wires themselves are less liable to burn off. The paste or cement with which it is desirable to build up the ends may be of the same material as that used for forming the glower itself. I have obtained excellent results by pulverizing portions of glowers which have been previously prepared and heated to high temperatures and mixing the same with water, and, if desired, starch-paste may be added. Any suitable means for supporting the conducting-wires and securing electrical connections therewith may be employed.

For the purpose of obtaining the preliminary or starting heating of the glower various different means may be employed. Usually it is desirable that the heat should be applied only during the starting process and then withdrawn, although in some cases it may be desired to continue the extraneous heat while the lamp itself is in operation.

The temperature to which the glower must be brought in order to have sufficient conductivity to allow enough current to flow through it to maintain itself in that conductive condition varies somewhat with different materials and proportions.

In the accompanying drawings, Figure 1 is a view, partly in diagram, of a complete lamp; and Fig. 2 is an enlarged view of the glower.

Referring to the figures, C represents a suitable base for supporting the lamp. It is provided with a circuit-closing device D, by means of which the circuit from any suitable source of electric currents G may be completed to the binding-posts c' c^2 of the lamp. The light-giving portion or glower A of the lamp is made in accordance with the description hereinbefore given. It is carried by two conductors a' a^2 of any suitable character, and these are connected with the terminals c' c^2 of the lamp. A bridge-piece a^3 may be employed for holding the conductors a' a^2 in their proper relative position. A heating or starting conductor B is shown in Fig. 1 as carried upon a glass or other transparent support b, and it incases to a greater or less extent the glower A. The circuit through the heater B is completed from the terminal c' through the wire 2, circuit-closer or switching device s, of any suitable character, and conductor 3 to one terminal of the heater, the other terminal being connected by the conductors 4 and 6 to the remaining terminal c^2 of the lamp. The terminals c' c^2 are connected across the circuit L' L^2. The glower itself is connected in parallel circuit with the heater by way of conductors 5 and 6 and the supporting-wires a' and a^2. When the switches D and s are closed, the current passes through the heater B, raising the glower A to such a temperature as will render it sufficiently conductive to be traversed by a current from the generator. The circuit through the heater may then be interrupted by the switch s, or in some cases it may remain in circuit while the lamp is in operation; but in such case the watts expended in the heater or starting-conductor B should be as few as possible consistent with its function of heating the glower.

The lamp itself may be, if desired, inclosed in a protecting-globe E, of any suitable character; but it is not necessary that it should be incased at all, as it will operate in the air. As the light emitted by the glower is very intense, it may be desirable in some cases to use a so-called "opalescent" globe or other means to diffuse the light. The globe E may be held in place in any convenient manner—as by clips e e, for instance.

In cases where there is liable to be an undue increase in the amount of current flowing through the glower when placed upon a constant-potential circuit means, such as indicated at R, may be employed for preventing such an increase. The device R is shown as being placed in series with the lamp itself, and, as hereinbefore explained, may consist of a properly-proportioned resistance or impedance coil, according to the character of the circuit. For continuous-current circuits the resistance may be made of a suitable metal of high specific resistance—such, for instance, as platinum or iron—and properly proportioned to prevent an increase of current through the lamps except under the influence of an increase of potential. In the case of lamps used on an alternating-current circuit properly proportioned reactive or impedance coils may be used.

Although I have described the invention more particularly with reference to open-air use, I desire it to be understood that it may also be used in vacuum-chambers, if desired.

It will be understood that the invention contemplates the use of the device herein claimed in connection with various different forms of heating or starting devices and arrangement of circuits and apparatus, the apparatus described in the drawings being illustrative merely of one general organization.

In the original application, Serial No.

679,081, filed April 28, 1898, of which this application is a division, the method involved in the operation of this apparatus is described and claimed, and in other divisional applications from the same original specific claims are made to other features of the apparatus not claimed herein.

The present application is, in accordance with the requirements of the Patent Office, divided out of an application, Serial No. 718,624, filed May 29, 1899, as a division of the original application mentioned in the preceding paragraph.

I claim as my invention—

1. A circuit connection between conductors of the first and solid conductors of the second class, consisting of a material composed mainly of conductors of the second class.

2. A circuit connection between conductors of the first and solid conductors of the second class, consisting of metal oxid similar in composition to a conductor of the second class.

3. A circuit connection between conductors of the first and solid conductors of the second class, consisting of metal oxid similar in composition to a conductor of the second class and a suitable vehicle.

4. A glower for electric lamps whose body is composed throughout of a mixture of two or more substantially pure oxids of rare earths.

5. A glower for electric lamps adapted to be operated in air whose body is composed throughout of a mixture of the oxids of rare earths, and conductors secured to the terminals thereof.

6. A glower for electric lamps adapted to be operated in air consisting of a mixture of the oxids of rare earths, conductors secured to the terminals thereof, and deposits of the rare earths at the junction of the glower with the metallic conductors.

7. A glower for electric lamps whose body is composed throughout of a mixture of oxids of zirconium and yttrium, the oxids of zirconium preponderating in amount.

8. As a material for connecting the points of contact between conductors of the first and of the second class, a mixture composed of one or more of the oxids of rare earths.

9. The combination with a luminant composed of a conductor of the second class, a metallic conductor connected with the end thereof, and a cement uniting the same composed of material like that composing the luminant.

10. A glower for electric lamps whose body is composed throughout of two or more rare-earth oxids intimately mixed.

Signed by me at Berlin this 27th of March, 1901.

WALTHER NERNST.

Witnesses:
HENRY HASPER,
WOLDEMAR HAUPT.