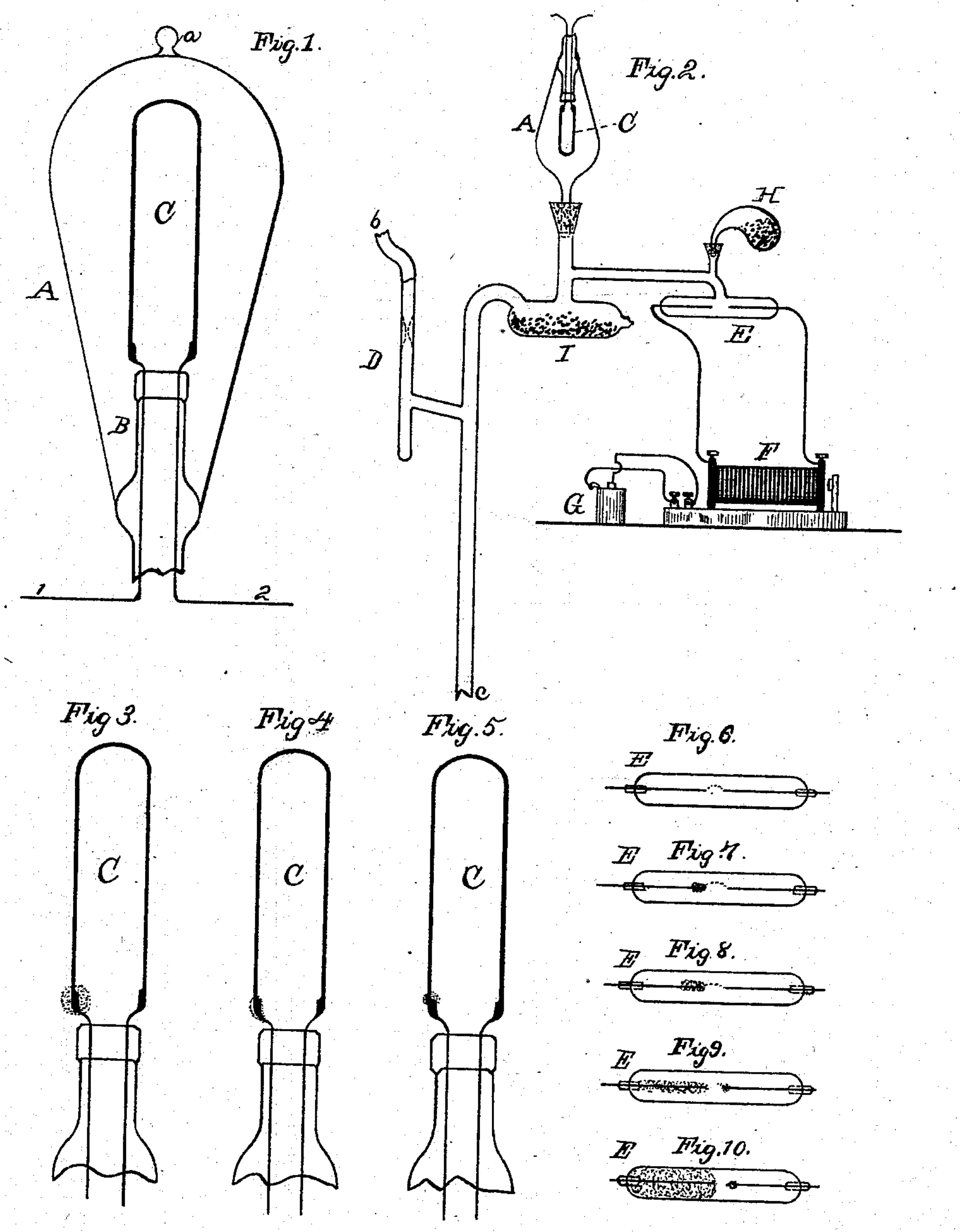
(No Model.)

T. A. EDISON.

INCANDESCENT ELECTRIC LAMP.

No. 274,295. **Patented Mar. 20, 1883.**



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INCANDESCENT ELECTRIC LAMP.

SPECIFICATION forming part of Letters Patent No. 274,295, dated March 20, 1883.

Application filed November 23, 1882. (No model.)

To all whom it may concern:

Be it known that I, THOMAS A. EDISON, of Menlo Park, in the county of Middlesex and State of New Jersey, have invented a new and useful Improvement in Incandescing Electric Lamps, (Case No. 516,) of which the following is a specification.

This invention relates to incandescing electric lamps, wherein flexible filaments of carbon are inclosed in hermetically-sealed chambers made entirely of glass, with leading-in wires passing through and sealed into the glass; and the object of the invention is principally to lengthen the life of electric lamps of this character by diminishing the electrical carrying between the flexible carbon filament and the inclosing-chamber, or the metallic terminals of the filament within the lamp, and incidentally to increase the resistance of the lamp, so as to reduce the investment required for conductors.

Heretofore in electric lamps of this character it has been the general practice to produce high vacua in the glass globes previous to hermetically sealing the same, in order to preserve the carbon filaments from oxidation and to prevent the loss caused by convection of heat which takes place when the globes are filled with an inert gas.

The improvements made by me in the past upon my standard incandescing electric lamps have been principally by increasing the resistance of the flexible carbon filaments without a corresponding increase of the radiating-surface and without diminishing in the least the degree of vacuum; but I find that advance in this direction is limited by reason of the increased deposit of the carbon upon the walls of the glass chamber, obscuring the light and diminishing considerably the exterior candle-power of the lamp, and also consuming and destroying the fine filament, reducing materially the length of life of the lamp.

I have found that the amount of deposit in any given period depends generally upon the degree of incandescence per unit surface to which the carbon filament is raised, the higher the degree of incandescence the more rapid being the deposit. It also depends upon the state of the vacuum, the higher the vacuum the greater being the deposit. This deposit I have discovered is due to electrical carrying of the carbon of the filament, the phenomenon being similar to that which takes place in the well-known Geissler tubes, wherein at certain stages of the vacuum or pressure electrical carrying of the platina forming the terminals takes place, blackening the walls of the glass vacuum-chamber, notwithstanding the platina is scarcely above the temperature of the atmosphere, while at other stages of the vacuum or pressure this blackening does not take place.

I have also discovered that the economy of the carbon-filament lamp (the number of standard lamps per horse-power) increases as the pressure within the globe diminishes, up to a certain stage of the vacuum, when any higher exhaustion does not practically increase the economy. If the vacuum is diminished below this point of greatest economy to prevent electrical carrying, the economy of the lamp is diminished, since the residual air acts as a carrier of heat to the walls of the chamber, where it is rapidly dissipated; but, owing to the greatly diminished electrical carrying of the carbon from the filament when the vacuum is low, I am enabled to diminish the radiating-surface, so as to raise each unit of surface to a higher degree of incandescence than would be practicable were the vacuum higher and the electrical carrying at its maximum; and as an increase in the degree of incandescence is an advance in the direction of economy, I am enabled to regain, by the economy of higher incandescence, the energy lost by the increased convection of heat from the filament to the glass walls of the lamp, caused by the greater density of the residual gas due to a low vacuum; hence a carbon-filament lamp embodying these conditions of low vacuum and high incandescence and resistance will have a longer life than if the vacuum were higher, and its candle-power will not be diminished by the obscuration of the globe by a deposit of carbon. It will also permit of a reduction in the size of conductors for carrying the current to and from the lamps by reason of its increased resistance, and the filament itself will be more flexible and less liable to break.

In carrying out the invention the flexible carbon filament is produced by the carbonization, under strain or pressure, of any suitable organic or inorganic material, reduced or not reduced to an amorphous or semi-amorphous condition in the way now well understood. The filament before carbonization, however, may be reduced to a smaller cross-section than usual heretofore, in order to produce the reduction of radiating-surface and increase of resistance per unit of radiating-surface necessary to compensate for the loss caused by the reduced vacuum. For illustration, it may be stated that the radiating-surface can be reduced in size two-tenths; but the sizes of filaments used by me at present may be retained, the loss in economy being more than counterbalanced by the increased length of life. The flexible carbon filament is secured to the leading-in wires, which are sealed in one glass part of the lamp, and this part is fused to the glass globe of the lamp in the usual or any suitable way. The lamp is then connected with a Sprengel pump, and the globe exhausted until a high vacuum is obtained, so as to remove all oxygen from the globe. During the latter part of the operation of exhausting the lamp the flexible carbon filament may be gradually raised to an incandescence higher than that at which it is intended afterward to be used; but this heating of the filament may be omitted. After the exhaustion of the lamp-globe is completed an inert gas is allowed to pass into the globe, gradually reducing the vacuum and increasing the pressure within the globe. This is preferably done by providing the pump with a tube containing a solid substance, which, when heated, will evolve an inert gas. The heat is applied at the proper time to the exterior of the tube containing the substance. The flexible carbon filament is raised to incandescence during the time that the inert gas is being admitted into the lamp-globe and certain phenomena will be noticed during this period. As the pressure gradually increases a light-blue halo very much spread out will appear upon the positive clamp of the filament. As more gas passes in, the halo will increase in density and hug the clamp. At this pressure carbon from the filament is deposited on the clamp in considerable quantity, which is due to the increase of the electrical resistance of the vacuum and the consequent prevention of deposit upon the globe. If, now, the pressure be further increased, the blue halo leaves the metallic portions of the clamp and appears on the carbon at the juncture of the latter and the metal of the clamp. If, now, the pressure is carried beyond this point, the blue halo will disappear entirely, and the resistance of the residual gas will be so great as to nearly or quite extinguish the electrical carrying. The proper stage being reached, the lamp is sealed off from the pump while incandescent.

The particular pressure at which the lamp should be sealed off is dependent upon the nature of the residual gas. With nitrogen for the inert gas this pressure may be when a mercurial column connected with the lamp stands at a height of about twenty inches; but with hydrochloric-acid gas, on account of its greater electrical resistance, the pressure may be somewhat reduced. At twenty-nine inches with nitrogen and equivalent pressure with other gasses the electrical carrying is greatly diminished. This vacuum of twenty-nine inches or below that height for nitrogen and equivalent pressures with other gases is what I hereinafter term a "low vacuum."

Since the blue halo in the lamp disappears altogether to the eye when a certain pressure is reached, on account of the incandescence of the filament, and since the operation should be carried beyond this point, a Geissler spark-gage may be used to determine the exact point to seal off the lamp, the terminals of the Geissler spark-gage being connected to an induction-coil worked by a constant battery. A mercurial column may be used for the purpose; but the Geissler spark-gage is preferred, for the reason that the electrical carrying depends, where the vacuum is low, both upon the nature of the residual gas and the pressure, which conditions will also affect the Geissler spark-gage, in which the phenomena due to electrical carrying can be observed after their disappearance to the eye in the lamp, while the mercurial column is only affected by the pressure.

The different degrees of exhaustion at which certain phenomena will appear in the spark-gage depend upon the size and distance apart of the electrodes, as well as on the chamber of the gage and on the electro-motive force of the coil; hence it is necessary to determine, in the first instance, by the disappearance of the blue halo from the clamps of the filament, due to increased pressure, the appearance of the spark-gage at the exact moment when the lamp is to be sealed off, which is an increased pressure of several inches of a column of mercury after the disappearance of the halo from the metallic terminals of the filament. The residual gas might be allowed to flow in until the gas within the globe is at atmospheric pressure, and good results would be obtained as far as the electrical carrying is concerned; but the economy would be considerably diminished without a corresponding increase of the life of the filament; hence it is best to diminish the pressure for the sake of economy, but not to the point where the blue halo begins to appear on the metallic terminals of the filament.

Instead of exhausting to a high vacuum with a mercury-pump, and then gradually reducing the vacuum to the proper point by means of an inert gas, the lamp is first exhausted to a high vacuum, and the inert gas is then allowed to flow into the lamp until the vacuum is reduced to atmospheric pressure, when the inert gas may be pumped out until the desired pressure is obtained; or any other way of displacing the oxygen by an inert gas and obtaining the desired pressure may be employed.

The making of the inclosing-chamber entirely of glass, through which the leading-in wires are passed and in which they are sealed, and the hermetical closing of such glass inclosing-chamber, assure the retention of the same conditions of pressure that it is found desirable to give the lamp when manufactured, which is a feature of essential importance in lamps with a low vacuum, as well as with lamps having a high vacuum. Since electrical carrying takes place also with incandescing conductors made of other material than carbon, I do not wish to limit myself to carbon, but intend to include all flexible filamentary incandescing conductors having, like carbon, a high specific resistance.

In the accompanying drawings, Figure 1 is a view of the lamp; Fig. 2, an elevation showing the principal parts of the pump and the devices connected therewith. Figs. 3, 4, and 5 illustrate the phenomena that appear at the positive clamp of the filament, and Figs. 6, 7, 8, 9, and 10 illustrate the phenomena that appear in the Geissler spark-gage.

A is the glass lamp-globe, fused to the inside glass part, B, through which pass the leading-in wires 1 2, such wires being sealed into the upper end of B by the fusion of the glass around and upon them.

C is the flexible carbon filament, secured to the leading-in wires in any suitable way. The globe A is provided with an inert gas at a low vacuum or atmospheric pressure, as before described, and is sealed at *a*.

D is the Sprengel pump, the mercury entering at *b* and passing out at *c*.

E is a Geissler spark-gage, connected with the exhaust-tube of the pump. Its terminals are connected with an induction-coil, F, worked by a constant battery, G.

H is a chamber or tube, also connected with the exhaust-tube of the pump. The tube H contains the solid material for producing the inert gas when the tube is heated. This material may be, for illustration, solid cyanide of mercury, which evolves cyanogen when heated. Other inert gases may, however, be used, being evolved from the decomposition of different salts by heat. The exhaust-tube may be connected with a reservoir of pure inert gas which can be allowed to pass, as desired, into the vacuum by means of a stop-cock; but the method first described is preferred, since it is quite impracticable to manipulate the gas or make it free from oxygen. This difficulty is not met with when the gas is evolved from a solid in a tube by the application of heat to the exterior of the tube, and the heat can be so applied as to set free the exact quantity of gas desired, the quantity being regulated with a nicety and exactness which cannot be obtained with a stop-cock.

I is a chamber or tube containing a drying agent.

Figs. 3, 4, and 5 represent the appearance of the blue halo on the positive clamp at three stages; Fig. 3, when it first appears, which corresponds with nitrogen for the inert gas, to a pressure shown in the mercury column of thirty and three-sixteenths inches; Fig. 4, when it becomes dense and hugs the clamp, which occurs at a pressure of twenty-nine and nine-sixteenths inches; and Fig. 5, when it is about to disappear, which occurs at a pressure of twenty-eight and fifteen-sixteenths inches. Figs. 6, 7, 8, 9, and 10 represent the phenomena of the spark-gage. Fig. 6 shows the spark between the terminals at the atmospheric pressure. Fig. 7 shows a halo on the end of the positive pole, which occurs at twenty inches. Figs. 8 and 9 show it extending along the wire, which occurs at about twenty-nine and five-eighths inches; and Fig. 10 shows the halo spread out so as to touch the walls of the tube, which occurs at thirty and one-fourth inches of the mercury column.

What I claim is—

1. An incandescing electric lamp having, in combination, the following three elements, viz: a flexible carbon filament, an inclosing-chamber, and an inert gas having the definite high pressure described, whereby electrical carrying of the carbon to the walls of the inclosing-chamber or the metallic terminals of the filament within the lamp is prevented, substantially as set forth.

2. An incandescing electric lamp having, in combination, a flexible carbon filament, a hermetically-sealed inclosing-chamber made entirely of glass, leading-in wires passing through and sealed into the glass, and an inert gas having the definite high pressure described, for the purpose set forth.

3. The method of completing incandescing electric lamps having flexible carbon filaments and inclosing-chambers entirely of glass, consisting in exhausting the inclosing-chambers until a high vacuum is obtained for removing the oxygen, then filling the chambers with an inert gas at a pressure sufficiently high to cause the disappearance of the blue halo from the positive clamp of the filament, and then hermetically sealing the chambers by a fusion of the glass, substantially as set forth.

4. The method of completing incandescing electric lamps having flexible carbon filaments and inclosing-chambers entirely of glass, consisting in exhausting the inclosing-chambers until a high vacuum is obtained for removing the oxygen, then raising the filaments to incandescence, then filling the chambers with an inert gas at a pressure sufficiently high to cause the disappearance of the blue halo from the positive clamp of the filament, and then hermetically sealing the chambers by a fusion of the glass while the filaments are incandescent, substantially as set forth.

5. The method of completing incandescing electric lamps, consisting in exhausting the lamp, and at the same time exhausting a chamber connected with said lamp, and containing a material evolving an inert gas when heated, then heating such chamber externally to evolve the gas, then filling the lamp with the inert gas at a pressure sufficiently high to cause the disappearance of the blue halo from the positive clamp of the filament, and then sealing off said lamp from connection with said chamber and the exhausting apparatus, substantially as set forth.

This specification signed and witnessed this 14th day of November, 1882.

THOS. A. EDISON.

Witnesses:

WM. H. MEADOWCROFT,
EDWARD H. PYATT.