A.D. 1886, *9th February.* N° 1877.

PROVISIONAL SPECIFICATION.

Improvements in Electric Lamps.

I Nikola Tesla, formerly of Smiljan Lika, border Country of Austro-Hungary, but now of Main Street, Rahway, State of New Jersey, United States of America Electrician do hereby declare the nature of this invention to be as follows:—

In these improvements I make use of two helices, one in a shunt and the other in the main circuit that includes the carbons.

An armature lever swings between the upper ends of the cores of these helices and at the other ends of the cores are pole pieces between which is an armature that is connected to a tubular clamp around the upper carbon holder, and this tubular clamp is suspended from the aforesaid armature lever. The cores and pole pieces of said helices, the swinging armature lever and the armature of the clamp, form a compound magnet.

The electric current passes from the + binding post through the shunt helix of high resistance to the — binding post, also from the + binding post the current passes through the carbon holders and carbons to the main line helix, and a branch from this helix goes to the — binding post and the end of said helix is connected to one of the pole pieces of the shunt magnet and is insulated. When the energy of the shunt core is increased by the increased resistance of the arc, the clamp is moved to allow the carbons to feed, and when the current through the shunt is abnormally strong, the armature of the clamp coming into contact with the pole of the shunt magnet, closes a branch circuit, that allows the electric current to pass through the clamp and the branch and a part of the main helix to the negative binding post, so that the continuity of the circuit is preserved and the shunt magnet is not injured, and as soon as the carbons come into contact and a path for the current is re-established through them, the carbons are separated to form the arc.

The ends of the swinging armature lever are curved, so also are the adjacent pole pieces of the respective cores and the poles at the other ends of the cores converge to the faces that act upon the armature at the bottom of the tubular clamp, and there is a spring that tends to swing the armature clamp away from the aforesaid insulated pole pieces.

Dated this 9th day of February 1886.

BREWER & SON,
For the Applicant.

COMPLETE SPECIFICATION.

Improvements in Electric Lamps.

I, NIKOLA TESLA, formerly of Smiljan Lika, border Country of Austro-Hungary, but now of Main Street, Rahway State of New Jersey, United States of America, Electrician, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

My invention relates more particularly to those arc-lamps in which the separation and feed of the carbon electrodes, or their equivalents, is accomplished by means of electro-magnets or solenoids in connection with suitable clutch mechanism and it is designed to remedy certain faults common to the greater part of the lamps heretofore made.

The objects of my invention are to prevent the frequent vibrations of the movable electrode and flickering of the light arising therefrom, to prevent the electrodes falling into contact, to dispense with the dash-pot, clock work or gearing and similar devices heretofore used and to render the lamp extremely sensitive and to feed the carbon almost imperceptibly and thereby obtain a very steady and uniform light.

In my present invention I further provide means for automatically withdrawing a lamp from the circuit or cutting out the same, when from a failure of the feed the arc reaches an abnormal length, and also means for automatically reinserting such lamp in the circuit when the rod drops and the carbons come into contact.

My invention will be understood with reference to the accompanying drawings in which

Fig. 1. is an elevation of the lamp with the case in section.

Fig. 2. is a sectional plan at the line x^1 x^1.

Fig. 3. is an elevation of the lamp partly in section, at right angles to fig. 1.

Fig. 4. is a sectional plan at the line *y. y.* fig. 1.

Fig. 5. is a section of the clamp in about full size.

Fig. 6. is a detached section illustrating the connection of the spring to the lever that carries the pivots of the clamp, and

Fig. 7. is a diagram showing the circuit connections of the lamp.

M. represents the main and N. the shunt magnet, both securely fastened to the base A. which with its side columns *s. s.* is preferably cast in one piece of brass or other diamagnetic material. To the magnets are soldered or otherwise fastened the brass washers or disks *a. a. a. a.* Similar washers *b. b.* of fiber or other insulating material serve to insulate the wires from the brass washers.

The magnets M and N. are made very flat so that their width exceeds three times their thickness or even more. In this way a comparatively small number of convolutions is sufficient to produce the required magnetism; besides a greater surface is offered for cooling off the wires.

The upper pole pieces *m. n.* of the magnets are curved as indicated in the drawing fig. 1; the lower pole pieces m^1 n^1 are brought near together tapering towards the armature *g.* as shown in figs. 2. and 4.

The object of this taper is to concentrate the greatest amount of the developed magnetism upon the armature and also to allow the pull to be exerted always upon the middle of the armature *g.*

This armature *g.* is a piece of iron in the shape of a hollow cylinder having on each side a segment cut away, the width of which is equal to the width of the pole-pieces m^1 n^1.

The armature is soldered or otherwise fastened to the clamp *r.* which is formed of a brass tube provided with gripping-jaws *e. e.* fig. 5.

These jaws are arcs of a circle of the diameter of the rod R. and are made of some hard metal, preferably of hardened German Silver. I also make the guides *f. f.* through which the carbon holding rod R slides, of the same material.

This has the advantage to reduce greatly the wear and corrosion of the parts coming in frictional contact with the rod which frequently causes trouble.

The jaws *e. e.* are fastened to the inside of the tube *r.* so that one is a little lower than the other.

The object of this is to provide a greater opening for the passage of the rod when the same is released by the clamp.

The clamp *r.* is supported on bearings *w. w* figs. 1. 3. and 5. which are just in the middle between the jaws *e. e*: I find this disposition to be the best. The bearings *w. w.* are carried by a lever *t.* one end of which rests upon an adjustable support *q.* of the side columns *s.* the other end being connected by means of the link e^1 to the armature lever L. The armature lever L. is a flat piece of iron in Z shape having its ends curved so as to correspond to the form of the upper pole pieces of the magnets M and N. It is hung upon the pivots *v.-v.* fig. 2. which are in the jaw *x.* of the top-plate B. This plate B. with the jaw is preferably cast in one piece and screwed to the side columns *s. s.* that extend up from the base A.

To partly balance the overweight of the moving parts, a spring s^1 figs. 2. and 6. is fastened to the top plate B. and hooked to the lever *t.*

The hook *o.* is towards one side of the lever or bent a little sideways, as seen in fig. 6. By this means a slight tendency is given to swing the armature towards the pole-piece m^1 of the main magnet to aid in clamping the rod.

The binding posts K. K^1 are preferably screwed to the base A. A manual switch for short circuiting the lamp when the carbons are renewed is also to be fastened to the base. This switch is of ordinary character and is not shown in the drawing. The rod R. is electrically connected to the lamp frame by means of a flexible conductor or otherwise.

The lamp case receives a removable ornamental cover s^2 around the same to enclose the parts.

The electrical connections are as indicated diagramatically in fig. 7.

The wire in the main magnet consists of two parts x^1 and p^1. These two parts may be in two separated coils or in one single helix as shown in the drawing. The part x^1 being normally in circuit is with the fine wire upon the shunt magnet wound and traversed by the current in the same direction so as to tend to produce similar pole pieces N. N. or *s. s.* on the corresponding pole pieces of the magnets M and N.

The part p^1 is only in circuit when the lamp is cut out and then the current being in the opposite direction produces in the main magnet, magnetism of the opposite polarity.

The operation is as follows :—

At the start the carbons are to be in contact and the current passes from the positive binding post K. to the lamp-frame, carbon-holder upper and lower carbon, insulated return wire in one of the side rods and from there through the part x^1 of the wire on the main magnet to the negative binding post. Upon the passage of the current, the main magnet is energized and attracts the clamping armature *g.* with sufficient force to clamp firmly the rod by means of the gripping jaws *e. e.* At the same time the armature lever L. is pulled down and the carbons separated.

In pulling down the armature lever L. the main magnet is assisted by the shunt magnet N. the latter being magnetized by magnetic induction from the magnet M.

It will be seen that the armatures L. & *g.* are practically the keepers for the magnets M. and N. and owing to this fact both magnets with either one of the armatures L and *g.* may be considered as one horseshoe magnet which might be termed a compound magnet. The whole of the soft iron parts $m.$ m^1 $g.$ $n.$ n^1 and L form a compound magnet.

The carbons being separated, the fine wire receives a portion of the current, now the magnetic induction from the magnet M. is such as to produce opposite poles on the corresponding ends of the magnet N. but the current traversing the helices tends to produce similar poles on the corresponding ends of both magnets and therefore as soon as the fine wire is traversed by sufficient current, the magnetism of the whole compound magnet is diminished. With regard to the armature *g* and the operation of the lamp, the pole m^1 may be termed as the clamping and the pole n^1 as the releasing pole.

As the carbons burn away, the fine wire receives more current and the magnetism diminishes in proportion. This causes the armature lever L. to swing and the armature *g.* to descend gradually under the weight of the moving parts until the end *p.* fig. 1. strikes a stop on the top-plate B. The adjustment is such that when this takes place the rod R. is yet gripped securely by the jaws *e. e.*

The further downward movement of the armature lever being prevented, the arc becomes longer as the carbons are consumed and the compound magnet is weakened more and more until the clamping armature *g.* releases the hold of the gripping jaws *e. e.* upon the rod R. and the rod is allowed to drop a little shortening thus the arc. The fine wire now receiving less current, the magnetism increases and the rod is clamped again and slightly raised if necessary. This clamping and releasing of the rod continues until the carbons are consumed. In practice, the feed is so sensitive that for the greatest part of the time the movement of the rod cannot be detected without some actual measurement. During the normal operation of the lamp, the armature lever L. remains stationary or nearly so in the position shown in fig. 1. Should it arise that owing to an imperfection in the rod, the same and the carbon drop too far so as to make the arc too short, or even bring the carbons in contact, then a very small amount of current passes through the fine wire and the compound magnet becomes sufficiently strong to act as on the start in pulling the armature lever L. down and separating the carbons to a greater distance. It occurs often in practice that the rod sticks in the guides. In this case the arc reaches a great length until it finally breaks; then the light goes out and frequently the fine wire is injured.

To prevent such an accident I provide my lamp with an automatic cut-out.

This cut-out operates as follows:—When upon a failure of the feed the arc reaches a certain predetermined length, such an amount of current is diverted through the fine-wire that the polarity of the compound magnet is reversed.

The clamping armature *g.* is now moved against the shunt magnet N. until it strikes the releasing pole n^1. As soon as the contact is established, the current passes from the positive binding post over the clamp *r.* armature *g.* insulated shunt magnet and the helix p^1 upon the main magnet M. to the negative binding post. In this case the current passes in the opposite direction and changes the polarity of the magnet M. at the same time maintaining, by magnetic induction, in the core of the shunt magnet, the required magnetism without reversal of polarity and the armature *g.* remains against the shunt magnet pole n^1. The lamp is thus cut out as long as the carbons are separated, but the clamp has released its hold upon the rod hence the rod can drop by gravity so as to bring the carbons into contact.

The cut-out may be used in this form without any further improvement, but I prefer to arrange it so that if the rod drops and the carbons come into contact, the arc is started again. For this purpose I proportion the resistance of the part p^1 and the number of the convolutions of the wire upon the main magnet, so that when the carbons come into contact, a sufficient amount of current is diverted through the carbons and the part x^1 to destroy or neutralize the magnetism of the compound magnet. Then the armature *g.* having a slight tendency to approach to the clamping pole m^1 comes out of contact with the releasing pole n^1. As soon as this happens, the current through the part p^1 is interrupted and the whole current passes through the part x^1.

The magnet M. is now strongly magnetized, the armature *g.* is attracted and the rod clamped, at the same time the armature lever L. is pulled down out of its normal position and the carbon holding rod raised and the arc started.

In this way the lamp cuts itself out automatically when the arc gets too long and re-inserts itself automatically in the circuit if the carbons drop together.

It will be seen that the cut-out may be modified without departing from the spirit of my invention as long as the shunt magnet closes a circuit including a wire upon the main magnet and continues to keep the contact closed, being magnetized by magnetic induction from the main magnet.—It is also obvious to say that the magnets and armatures may be of any desired shape.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is

First. The combination in an arc-lamp, of a main and shunt magnet, an armature lever to draw the arc, a clamp and an armature to act upon the clamp, a clamping pole and a releasing pole upon the respective cores, the cores, poles, armature lever and clamping armature forming a compound magnet, substantially as set forth.

Second. The combination in an electric arc lamp, of a carbon holder and its rod, a clamp for such carbon holder, a clamping armature connected to the clamp, a compound electro-magnet controlling the action of the clamping armature, and electric circuit connections substantially as set forth for lessening the magnetism of the compound magnet when the arc between the carbons lengthens and augmenting the magnetism of the same when the arc is shortened, substantially as described.

Third. The combination with the carbon holders in an electric lamp, of a clamp around the rod of the upper carbon holder, the clamping armature connected with said clamp, the armature lever and connection from the same to the clamp, the main and shunt magnets and the respective poles of the same to act upon the clamping armature and armature lever respectively substantially as set forth.

Fourth. In an electric arc lamp, a cut-out consisting of a main magnet, an armature and a shunt magnet having an insulated pole piece, and the cut-out circuit connections through the pole piece and armature, substantially as set forth.

Fifth. In an electric arc lamp, the combination with the carbon holder and magnets, of the armatures L. and *g.* link e^1 clamp *r.* and lever *t.* and the springs s^1 for the purposes set forth.

Sixth. In an electric arc lamp the combination with two upright magnets in the main and shunt circuits respectively, having curved pole pieces on one end and converging pole pieces on the other end, of a flat Z shaped armature lever between the curved pole-pieces and a clamping armature between the convergent pole-pieces substantially as described.

Seventh. The combination in an electric arc lamp, of an electro-magnet in the main circuit and an electro-magnet in the shunt circuit, an armature under the influence of the poles of the respective magnets and circuit connections controlled by such armature to cut out or shunt the lamp substantially as specified, whereby the branch circuit is closed by the magnetism of the shunt magnet and then kept closed by induced magnetism from the main magnet, substantially as set forth.

Eighth. The combination with the carbon holder and rod and the main and shunt magnets, of a feeding clamp, an armature for the same, clamping and releasing poles upon the cores of the respective magnets and circuit connections through the clamping armature, substantially as specified for shunting the current when the arc between the carbons becomes abnormally long, substantially as set forth.

Ninth. The combination with the carbon holding rod and a clamp for the same, of an armature upon the clamp, a shunt magnet the pole of which acts to release the clamp, a main magnet with a two part helix, one portion being in the main circuit and the other portion in a shunt or cut-out circuit, the clamping armature acting to close said cut-out circuit when the arc becomes too long and to break the shunt circuit when the carbons come together, substantially as set forth.

Tenth. The combination with the carbon holders of two magnets one in the main circuit and the other in a shunt circuit and an armature lever to draw the arc and a feeding mechanism and pole-pieces upon the electro magnets to act upon the feeding mechanism substantially as specified.

Eleventh. The combination with the carbon-holders, of two magnets, one in the main circuit, and the other in a shunt circuit, an armature lever between two poles of such electro-magnets to draw the arc, pole pieces upon the other two poles of the electro-magnets, and a feeding mechanism between and acted upon by such pole pieces substantially as specified.

Twelfth. The combination with the carbon holder, of a tubular clamp surrounding the same, an armature lever connected to said tubular clamp and electro-magnets in the main and shunt circuits respectively and an armature upon the tubular clamp adjacent to the lateral poles of the electro-magnets, substantially as set forth.

Dated this 16th day of September 1886.

BREWER & SON,
For the Applicant.

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Fig. 1.

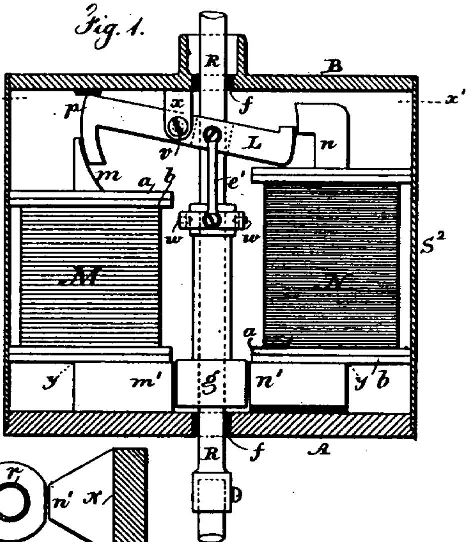

Fig. 4.

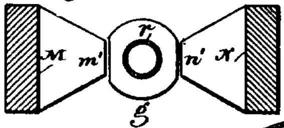

Fig. 2.

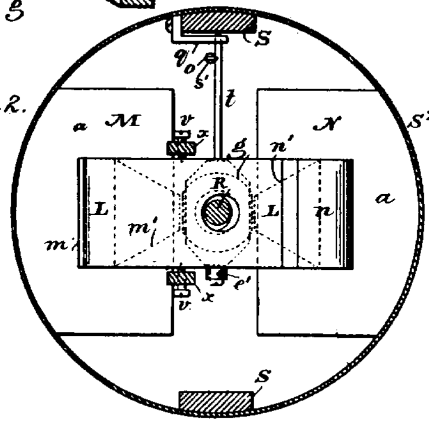

Fig. 3.

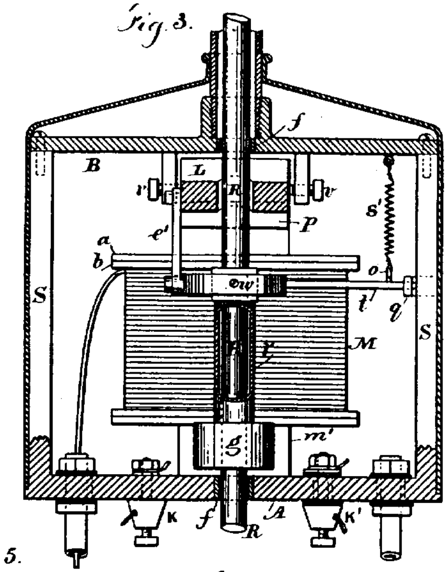

Fig. 6

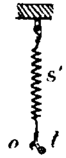

Fig. 5.

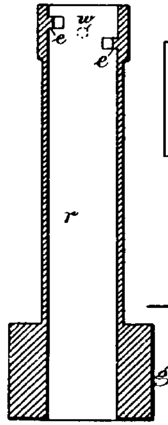

Fig. 7.