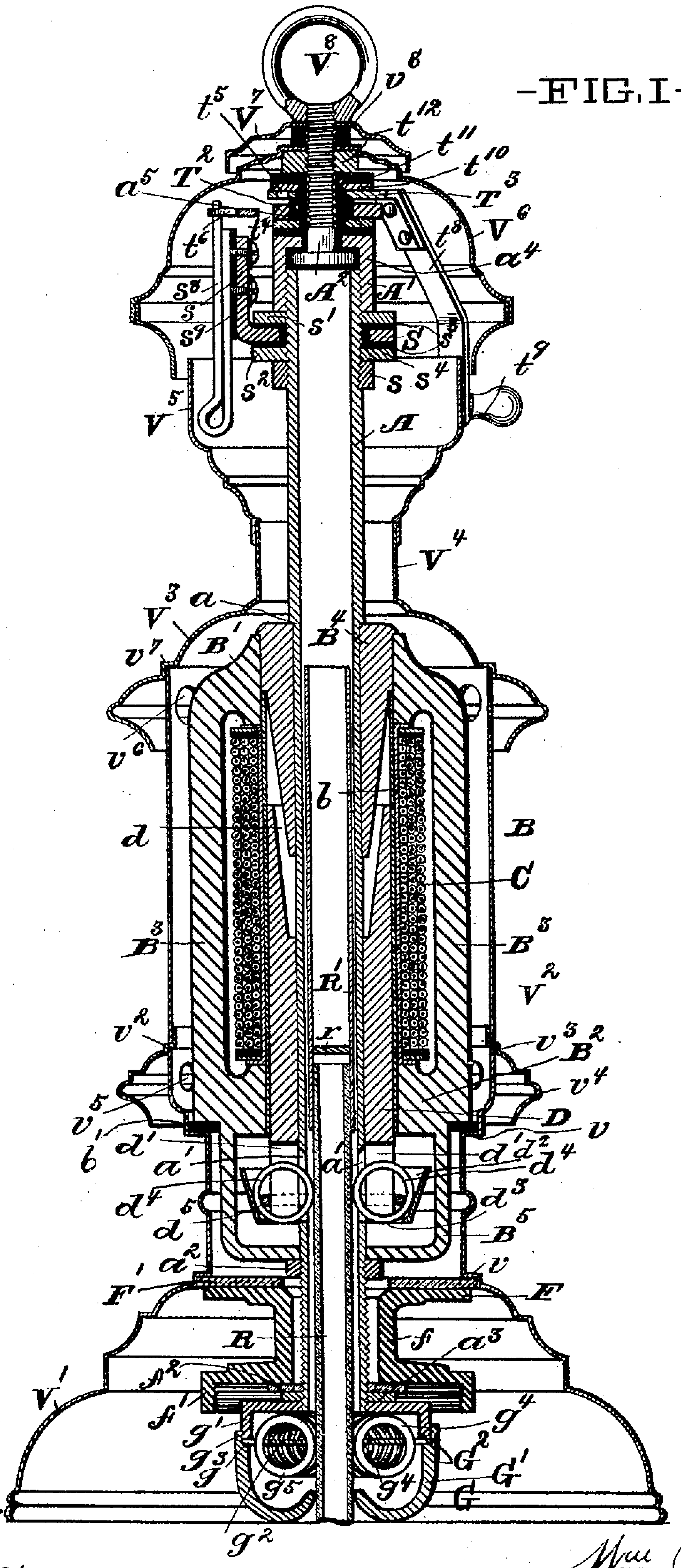
(No Model.) 4 Sheets—Sheet 1.

W. JANDUS.

ELECTRIC ARC LAMP.

No. 543,445. Patented July 23, 1895.

-FIG. I-



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Attys

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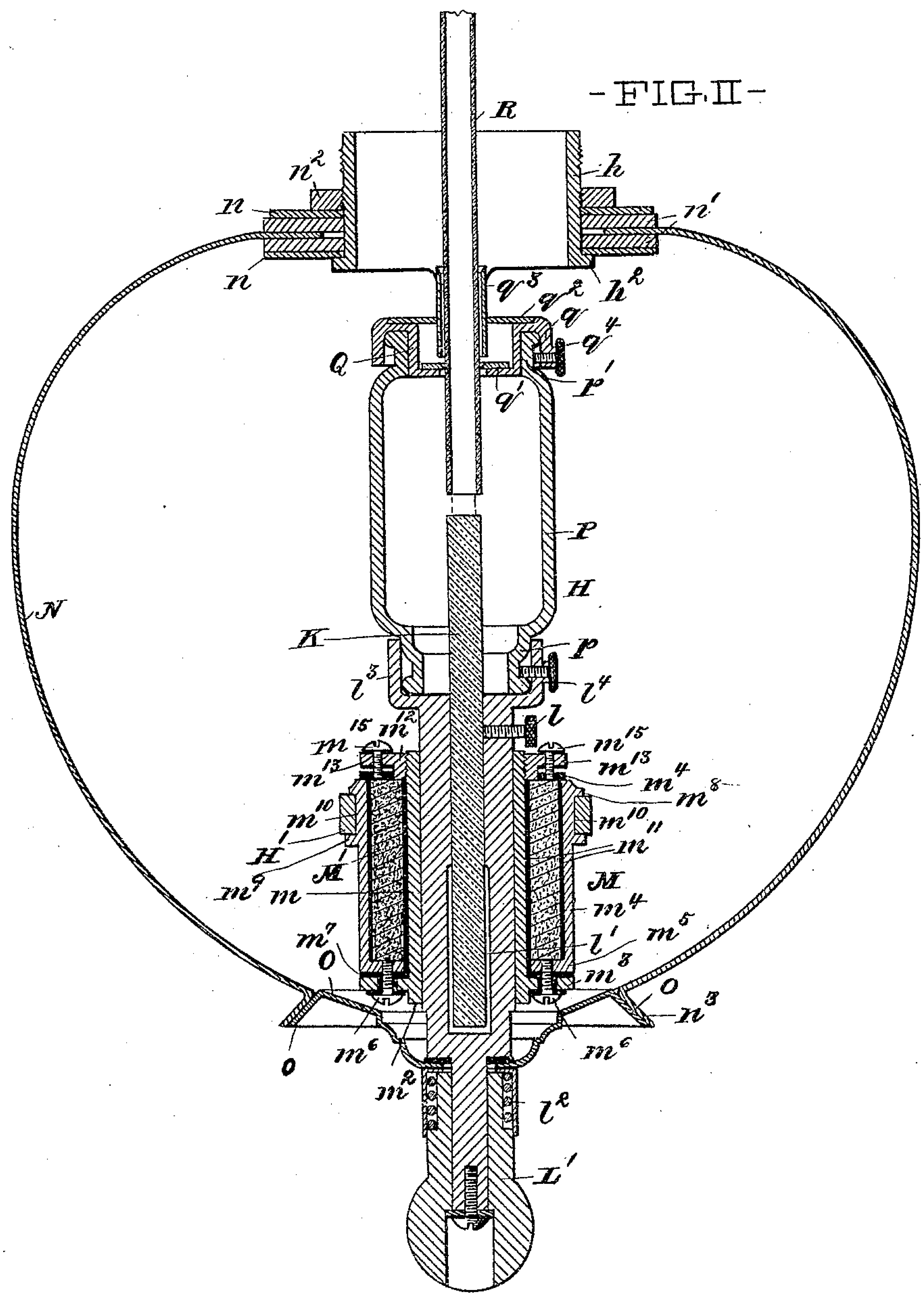
-FIG.II-



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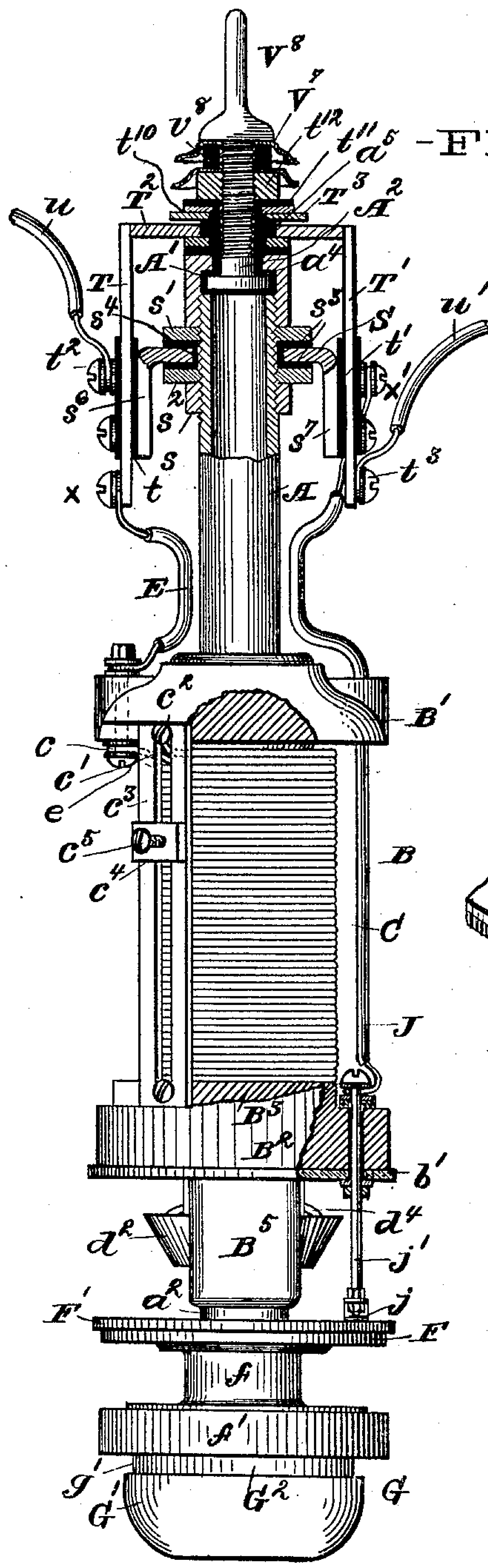
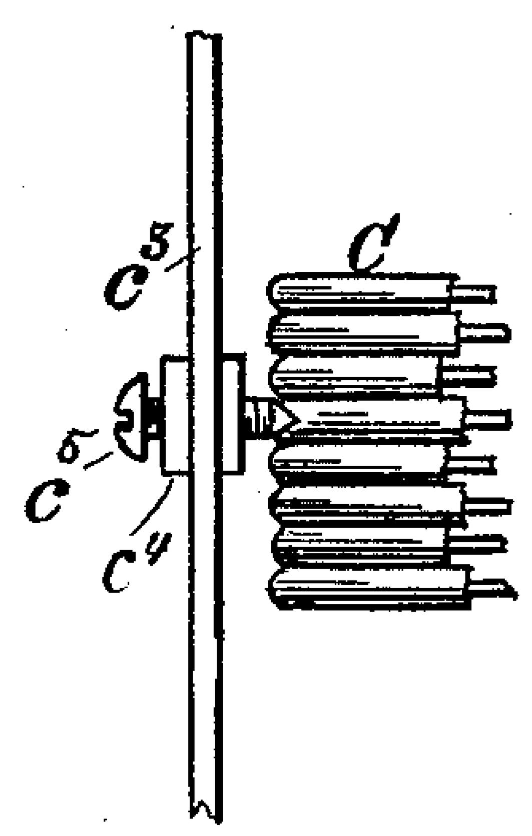
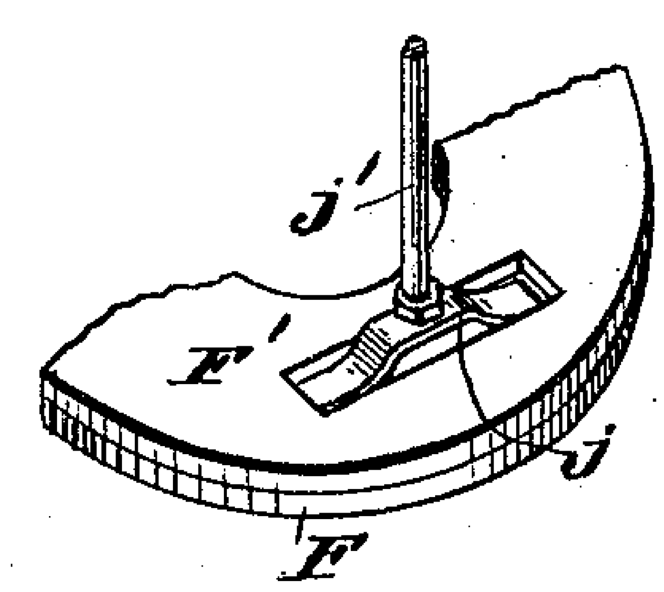
-FIG. III-



-FIG. IV-



-FIG. V-



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4 Sheets—Sheet 4.

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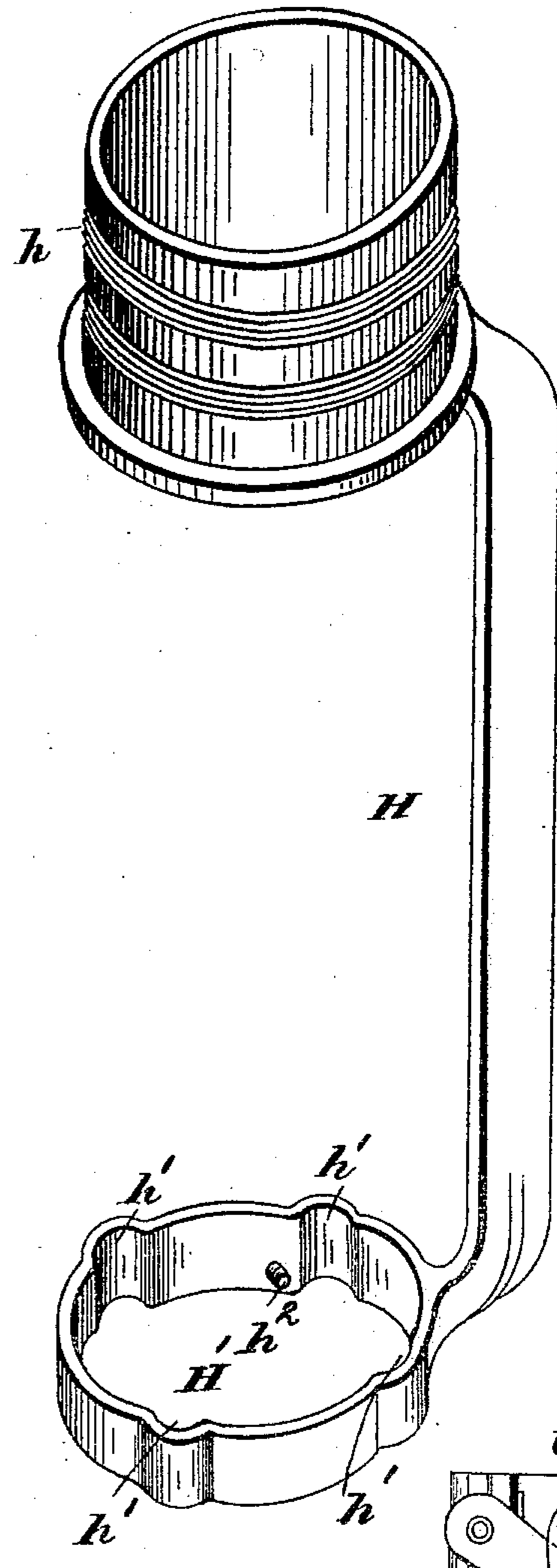
ELECTRIC ARC LAMP.

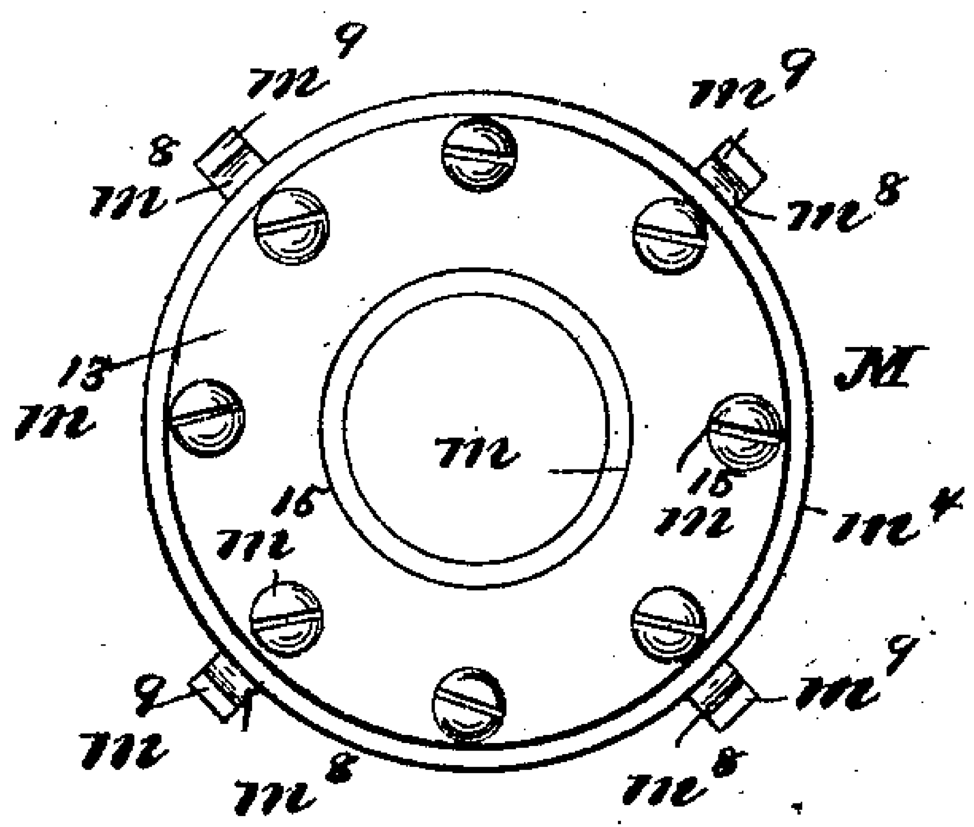
No. 543,445.

Patented July 23, 1895.

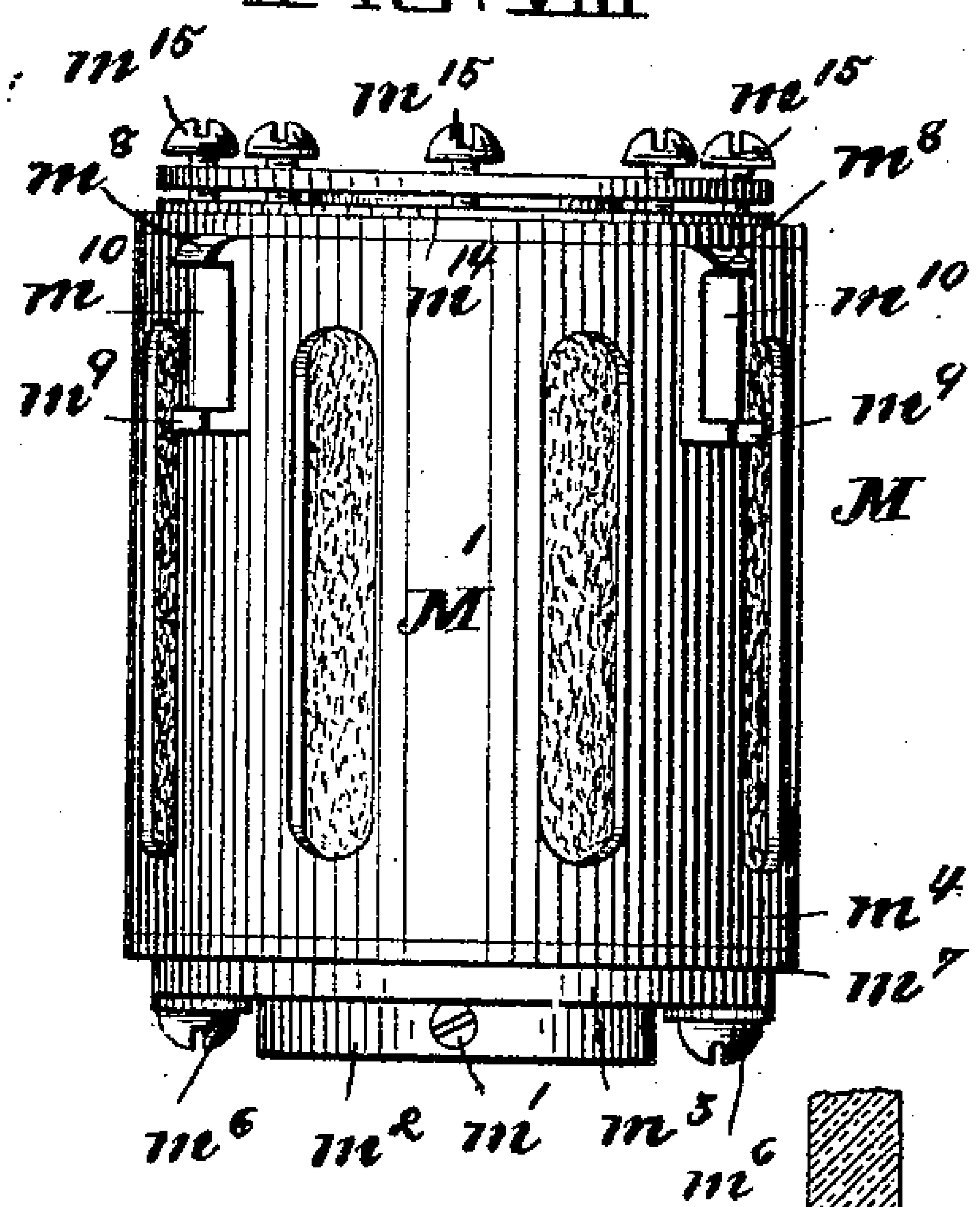
- FIG. VI -



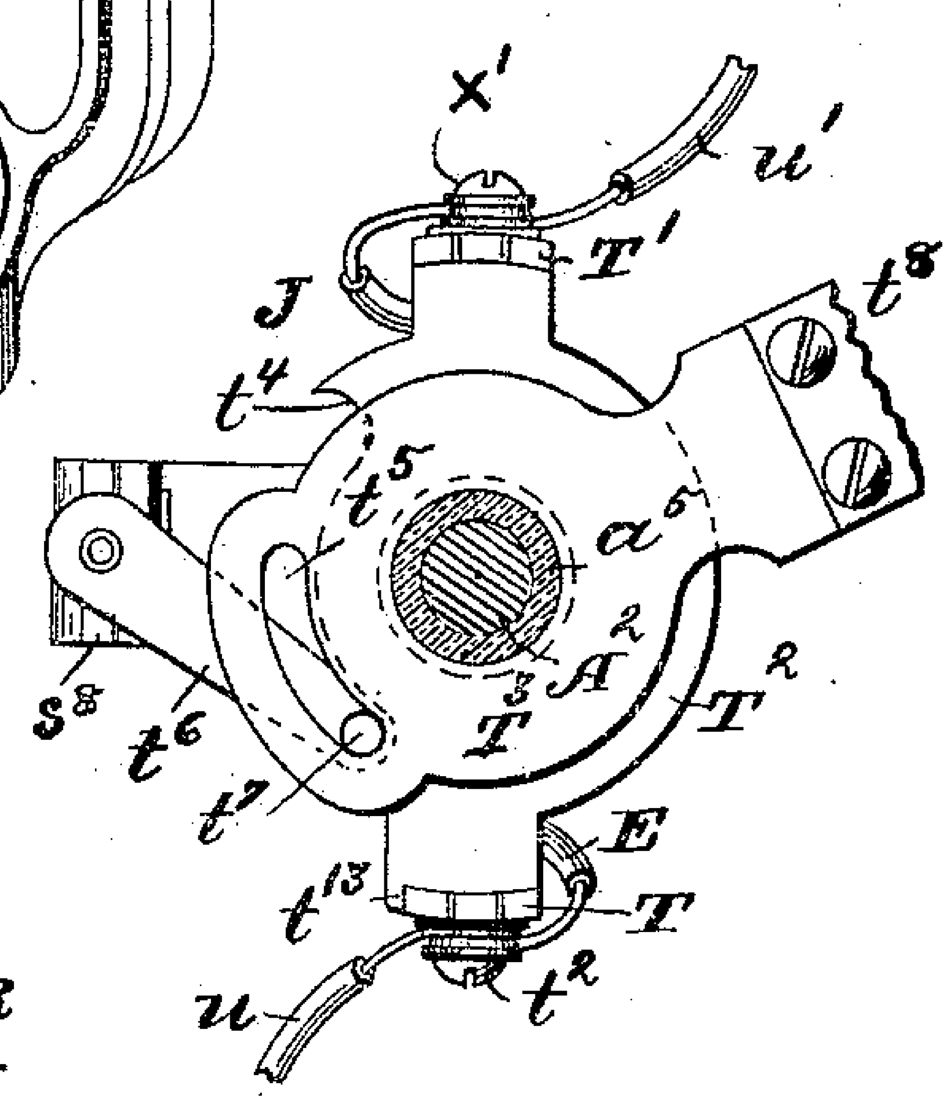
- FIG. VII -



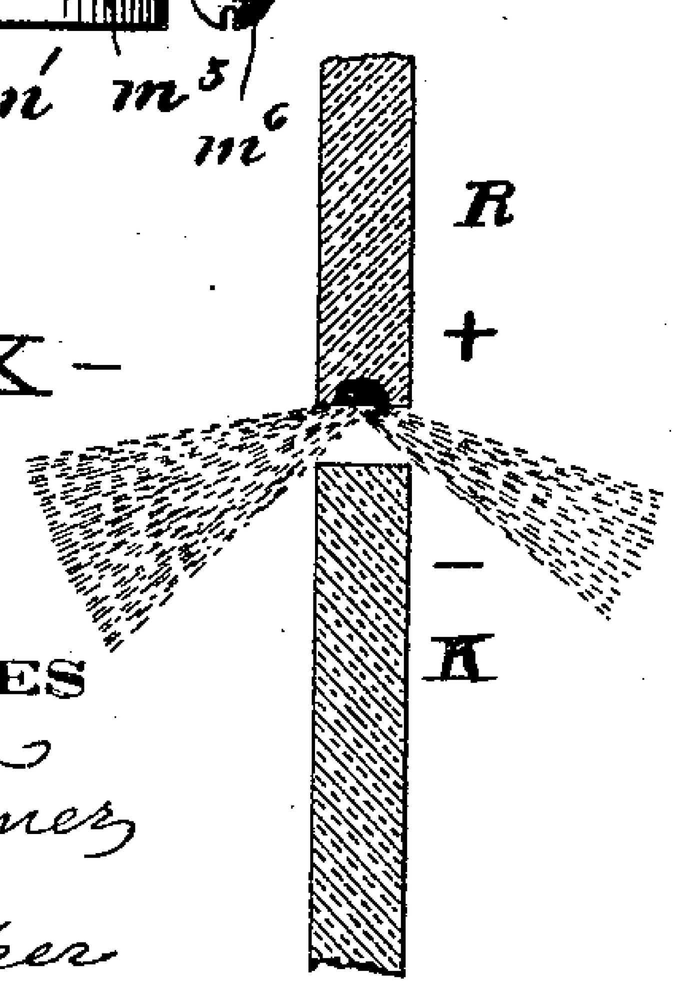
- FIG. VIII -



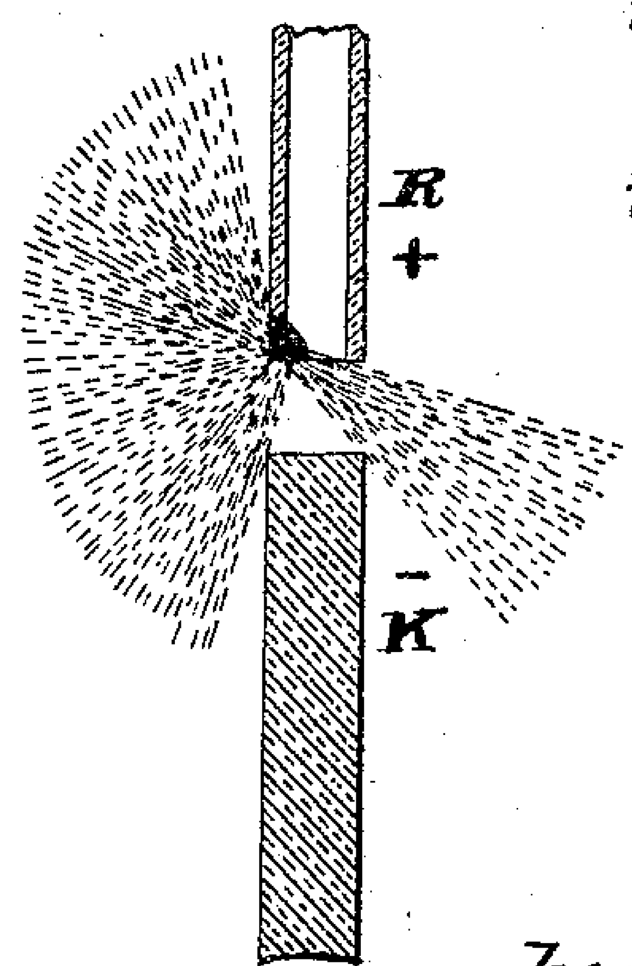
- FIG. IX -



- FIG. X -



- FIG. XI -



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UNITED STATES PATENT OFFICE.

WILLIAM JANDUS, OF CLEVELAND, OHIO.

ELECTRIC-ARC LAMP.

SPECIFICATION forming part of Letters Patent No. 543,445, dated July 23, 1895.

Application filed December 19, 1894. Serial No. 532,314. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM JANDUS, a citizen of the United States, residing at Cleveland, county of Cuyahoga, and State of Ohio, have invented certain new and useful Improvements in Electric Lamps, of which the following is a specification, the principle of the invention being herein explained, and the best mode in which I have contemplated applying that principle, so as to distinguish it from other inventions.

The annexed drawings and the following description set forth in detail one mechanical form embodying the invention, such detail construction being but one of various mechanical forms in which the principle of the invention may be used.

In said annexed drawings, Figure I represents an axial section of the upper portion of my improved electric lamp; Fig. II, an axial section of the lower portion of said lamp; Fig. III, a side elevation of the upper portion of the lamp removed from its casing and illustrating the upper portion of the lamp in axial section at right angles to the section illustrated in Fig. I and illustrating parts of the magnet-body as broken away and removed; Fig. IV, a detail view of the device for regulating the amount of resistance in the main coil; Fig. V, a perspective detail view of the spring-contact for the negative conductor in the lamp; Fig. VI, a perspective view of the negative-electrode-supporting frame; Fig. VII, a top view of the rheostat for the negative-electrode support; Fig. VIII, a side view of said rheostat; Fig. IX, a top view of the switch; and Figs. X and XI, detail views, respectively, of the carbons in an ordinary arc lamp and in my lamp, illustrating the conditions of the arc in said two forms.

The lamp has an axial electrode-containing tube A, which extends about the entire length of the upper portion of the lamp and forms the main frame part of the lamp structure, to which all other parts are secured or from which they are supported. This tube is formed with a shoulder *a*, against which the upper end of the axial bore of a magnet-body B bears. Said magnet-body consists of an upper annular portion B′ and a lower annular portion B^2, connected by two or more vertical wall portions B^3. The general outline of the magnet is thus substantially cylindrical with more or less open walls. A tubular portion B^4 is securely jammed into the opening of the upper annular portion of the magnet, and that much of this tubular portion as projects below the annular upper portion is reduced and formed truncate conical. A tube *b* of non-magnetic metal is secured around the upper end of the conical part of the tubular portion and into the opening of the lower annular portion of the magnet to form an air-tight annular chamber within the magnet-body, such chamber being formed between said tube *b* and the axial tube A, and decreasing in size toward its upper end on account of the conical part of the magnet projecting down into it.

A substantially right-angled stirrup-shaped yoke B^5 is formed upon the under side of the lower annular portion of the magnet, and has a central opening, which is concentric with the openings of the annular portions, registers with the axial bore in the truncate conical tubular portion, is of the same size as said bore, and fits snugly upon the axial carbon-containing tube A, whereby said tube is aligned absolutely true in its axial relation to the magnet, and whereby the tubular armature, which plays upon the axial tube and within the annular chamber of the magnet, will be guided absolutely true in its movement and will not be liable to bind within the chamber. A series coil C is placed within the walls of the magnet-body and around the tube *b*, which forms the outer wall of the annular chamber in the magnet. The tubular armature D is of such dimensions that it will have a snug but sliding fit upon the axial tube A and within the tube *b*, so that the armature will have an air-cushion to its up-and-down movements in the annular magnet-chamber. The axial bore of the armature has a truncate conical recess *d* in its upper end, which recess corresponds to the truncate conical inner tubular portion of the magnet. The lower end of the tubular armature is formed with longitudinal slots *d′*. A flaring pan d^2 is secured to the lower end of the armature and has radiating slots d^3, which register with the slots in the armature and with longitudinal slots *a′* in the axial tube A. Clutch-rings d^4 have vertical and radial play in the slots of the tube, armature, and pan, and are retained in their respective slots by means of a ring d^5, which passes through said clutch-rings, and is of a sufficient diameter to prevent the clutch-rings from dropping into the axial tube and become caught in the slots of the same when the electrode is withdrawn from the tube and the slots of the armature yet register with the slots in the axial tube. The lower ends of the slots in the axial tube are some distance above the yoke at the lower end of the magnet, so that the clutch-rings will be thrown outward in the pan when the armature is entirely released and drops down upon the yoke, whereby the clutch-rings can offer no resistance to the insertion of the electrode into the axial tube when the lamp is trimmed. The magnet is drawn up against the shoulder a upon the axial tube by means of a nut a^2 upon the lower screw-threaded end of said tube. One terminal c of the series coil is connected to the positive conductor E of the lamp by being clamped to a screw-bolt e, which passes through the upper annular portion of the magnet and is insulated from the same and which has said positive conductor secured to its upper end. The other terminal c' of the series coil is secured in contact with the magnet by a screw c^2, which enters the upper annular portion of the magnet and thereby causes the magnet to form a part of the conductor in the lamp. Said binding-screw c^2 also secures the upper end of a longitudinally-slotted bar c^3, of brass, copper, or similar good conducting material, to the upper annular portion of the magnet, and the lower end of said bar is secured to the lower portion of the magnet. A slide c^4 is movable upon the slotted bar, and a screw c^5 passes through said slide. The point of said screw is pyramidal or otherwise formed with edges or ridges, so as to form an insulator cutter, which may cut away the insulation from the outer windings of the series coil, and thus form a contact at the winding, against which it is brought to bear and from which it has cut the insulation, thereby cutting out the portion of the outer winding of the coil above the screw and short-circuiting the current through the slotted bar to the magnet-body. The number of ampère turns of the coil may thus be adjusted and regulated according to the Watt power to be consumed in the lamp.

An annular disk F has a downwardly-projecting neck f at its central opening, and an internally-screw-threaded cap f' is formed at the lower end of said neck. A nut a^3 fits upon the screw-threaded lower portion of the axial tube and supports the cap, neck, and annular disk, an insulating-washer f^2 being interposed between the nut and the under side of the cap.

A brush-holder G is secured to the lower end of the axial electrode-containing tube. Said brush-holder consists of an annular casing G′, the upper internally-rabbeted edge g of which is internally screw-threaded to receive the externally-screw-threaded flange g' of a cover G^2, which is formed with a central screw-threaded opening, which is screwed upon the lower end of the axial tube. A brush-support g^2, in the shape of an annular disk, has its outer edge supported upon the rabbet of the casing, and is secured upon said rabbet by the flange of the cover. The outer edge of said annular disk and the edge of the central opening have radiating and registering notches g^3 and g^4, respectively, into which notches brush-rings g^5 have radiating support and play. As the radiating brushes may project from all sides toward the central opening through the brush-holder, and as said brushes form parts of the positive conductor within the lamp, (being in contact with the support and holder, which is in contact with the axial tube, which again is in electrical contact with the magnet-body,) the annular brushes may have current-feeding contact with the positive electrode when the latter is inserted through the brush-holder and into the axial electrode-containing tube.

A negative electrode-supporting frame H has an externally-screw-threaded neck h at its upper end, which neck is screwed into the internally-screw-threaded cap f' of the negative-conductor disk F. Said disk is connected to the negative conductor J of the lamp by a spring-contact j, adjustably secured upon a rod j', which is secured through and insulated from the lower annular portion of the magnet. The negative conductor passes through and is insulated from the upper annular portion of the magnet and is secured in contact with the upper end of the rod j'. An insulating-washer F′ is placed upon the upper side of the negative-conductor disk, for a purpose which will be explained later, and said washer is cut away at the point where the spring-contact projects to bear against the disk, as clearly illustrated in Fig. V. A ring H′ is formed at the lower end of the negative electrode-supporting frame concentric with the neck of said frame and with the axis of the entire lamp structure. Said ring has a circular interior shape with notches h' at points of its circular interior, four equidistant notches being illustrated in the drawings and being illustrated as formed by outward bulges of the ring.

The negative electrode K is secured in a negative-electrode holder L by means of a set-screw l, which enters the axial socket of said holder. Said axial socket is intersected at its lower portion by a slot l' of greater width than the diameter of the socket, which slot gives access to the socket for the purpose of adjusting the carbon in the socket and for the purpose of removing the negative carbon from the same, if the carbon should become stuck in the socket or burned down to the upper end of the socket, so that it cannot be removed from the latter at the upper end of the same.

A rheostat M has an axial sleeve m in metallic contact with the electrode-holder and adjustably secured upon the latter by means of a set-screw m', passing through a collar m^2, at the lower end of the sleeve. The axial sleeve of the rheostat has a lateral flange m^3 projecting outward from near its lower end. A cylindrical casing m^4, of so much greater interior diameter than the exterior diameter of the sleeve as to leave an annular space between the casing and sleeve, has an inwardly-projecting flange m^5, through which passes screws m^6, which pass through and are insulated from the foot-flange m^3 of the inner sleeve. The two flanges are insulated from each other by means of an insulating-washer m^7. The cylindrical casing is formed with short lugs m^8 and longer lugs m^9 at points corresponding to the notches in the ring of the negative-electrode-supporting frame, so that the rheostat may be inserted through the ring from below, with the short upper lugs moving upward through the notches, whereupon the rheostat may be turned to bring the lugs to bear against the upper and lower edge of the ring at points between the notches, thereby securing the rheostat and negative carbon-holder in said ring. For the purpose of preventing the rheostat from being turned so far around that the lugs will again be brought to register with the notches, the lugs are preferably connected by vertical ribs m^{10}, one of which may strike a stop-screw h^2 upon one of the circular portions of the interior of the ring. The long lugs serve to prevent the rheostat from being pushed too far up through the ring. An annular cylinder M', of a compound containing carbon, is placed within the annular space between the casing and axial sleeve and is insulated from the surfaces of the same by insulating-sleeves m^{11}.

The lower end of the resistance-cylinder M' is in contact with the inwardly-projecting flange of the casing, and the upper end of the cylinder is in contact, near the inner edge, with a hub m^{12}, projecting downward from an annular disk m^{13}, screwed upon the upper end of the axial sleeve. The hub of the annular disk is the only portion of the same which is in direct contact with the resistance-cylinder, as an insulating-washer m^{14} is interposed. A number of screws m^{15}, however, pass through the annular disk and the insulating-washer, and one or more of said screws may be screwed down against the end of the resistance-cylinder.

As the outer casing of the rheostat is in metallic contact with the negative-electrode-supporting frame, which forms a part of the negative conductor of the lamp, and the lower portion of said casing is in electrical contact with the lower end of the resistance-cylinder, while the upper end of said resistance-cylinder is electrically connected to the negative-electrode holder, the current will pass through said holder, the axial sleeve and annular disk, the resistance-cylinder, the casing, and the electrode-supporting frame to the negative conductor, and the extent of electrical contact with the resistance-cylinder and consequently the amount of resistance to the passage of the current through the resistance-cylinder, which forms the resistance element, may be increased or decreased by placing a smaller or greater number of the contact-screws m^{15} in contact with the resistance element. By these means the relative resistances of the arc and rheostat may be adjusted.

A globe N, which forms the outer arc-inclosing chamber, has the edges of its top opening clamped between two metallic washers n with two interposed yielding washers n'. The lower metallic washer rests upon a flange h^3, projecting outward from the neck h of the negative-electrode-supporting frame, and a nut n^2 upon the external screw-thread of said neck serves to draw the washers together to clamp the edge of the globe. The bottom opening of the globe is formed with an outwardly-flaring flange n^3, against the under side of which a flange o upon a yieldingly-supported cover O may bear. Said cover slides upon an insulating-handle L', secured upon the lower end of the negative-electrode holder, and has a coiled spring l^2 bearing upward against it to force the cover yieldingly against the flared bottom opening of the globe.

The negative-electrode holder is formed with an upwardly-projecting flange l^3, which forms a seat for a circumferentially-grooved lower neck p of a globe P of substantially-cylindrical outline. A set-screw l^4 passes through the flange of the seat and enters the groove in the neck, thus securing the globe in its seat. The upper end of the globe, which forms the inner arc-inclosing chamber, is formed into a peripherally-grooved neck p', over which fits a downwardly-projecting flange q of a cover Q, which fits inside the neck. The cover is cup-shaped and has an opening in its bottom, which is partly covered by a washer q', through which the positive carbon passes. The top of the cup-shaped cover is covered by a disk q^2 secured in the rabbeted upper edge of the cover. A tube q^3 passes through the disk and serves as a passage and guide for the upper carbon. The upper edge of said tube and the central opening of the washer are inwardly beveled, so that the carbon will meet with no resistance when passed through the tube and washer. A set-screw q^4 passes through the flange of the cover and engages the groove in the neck of the globe, so as to retain the cover in position.

The positive carbon R is secured in the end of a carbon-sheath R', said sheath having a socket at one end, which is closed by a partition r in the sheath, so as to prevent draft from passing upward through the tubular carbon. I prefer to use a tubular carbon which has very thin walls, the cross-sectional area of the axial bore of the carbon being greater than the cross-sectional area of the solid portion of the carbon.

A cap A' is screwed upon the upper end of the axial tube A of the lamp structure, and a screw-bolt A^2 passes through said cap and has its head clamped between the upper end of the axial tube and the cap by the latter, being, however, insulated from the axial tube and cap by insulating-washers and packing a^4. A ring S is clamped upon the axial tube by means of a nut s upon the threaded upper portion of the tube, two metallic washers s' and s^2 being respectively above and below the ring and insulating-washers s^3 between the ring and metallic washers. The nut forces the ring and washers toward the cap A′ and thereby clamps the ring. The ring is insulated from the axial tube by a sleeve s^4 of insulating material. The ring has an upwardly-bent arm s^5 projecting from its edge, and has two downwardly-bent arms s^6 and s^7 diametrically opposite each other and at right angles to the upwardly-bent arm. A doubled spring s^8 is secured to the upwardly-bent arm and is insulated from the same by an insulating-plate s^9. Two contact-plates T and T′ are secured to the downwardly-bent arms s^6 and s^7 and are insulated from said arms by insulating-plates t and t'. The leads U and U′, respectively the negative and positive lead, are respectively connected to the downwardly-bent arm s^6 and to the contact-plate T′. The binding-screw t^2, which secures the negative lead, is inserted through the contact-plate T and the arm s^6, insulated from the former and in contact with the latter, and the positive lead is secured to the contact-plate T′ in direct contact with the same by a binding-screw t^3.

The positive conductor E of the lamp is connected in contact with the contact-plate T by means of a binding-screw x, and the negative conductor J of the lamp is connected in electric contact with the downwardly-bent arm s^7 by a binding-screw x', inserted through and insulated from the contact-plate T′ and in contact with the arm s^7. A contact-bar T^2 is pivoted at its middle upon an insulating-sleeve a^5, and a switch-lever T^3 is pivoted above said bar, the insulating-sleeve being so stepped as to admit of said bar and lever turning without one interfering with the movement of the other. The edge of the central portion of the contact-bar which presents toward the doubled spring is formed with a segmental notch t^4 extending from near one arm of the bar to a point slightly beyond the middle of the distance between the two arms. The switch-lever is formed with a segmental slot t^5 opposite the handle portion of the lever and slightly shorter than the notch in the contact-bar, with which notch it registers and is concentric. A connecting-arm t^6 is pivoted at one end to the free end of the doubled spring and has a pin t^7 projecting upward from its other end, which pin projects into and slides in the slot in the switch-lever. The end of the arm slides in the notch of the contact-bar and may engage the shoulders at the ends of said notch. The switch-lever has a handle t^8, which is insulated from the central portion of the lever, and which has a knob t^9 for manipulating it. The contact-bar and switch-lever are retained upon the insulated sleeve of the screw-bolt by a washer t^{10} and insulating-washer t^{11}, held downward by a nut t^{12} upon the screw-bolt. One arm of the contact-bar is provided with a stop-shoulder t^{13}, which may bear against the edge of the contact-plate with which its end is in contact, or both arms may be provided with such stop-shoulders, the object of the shoulder or shoulders being to stop the contact-bar with its ends in electric contact with the contact-plates. The entire lamp structure above the globe is inclosed in a casing which is supported by the parts of the lamp structure. The lower portion of said casing consists of a cylindrical casing V, formed with offsets v and v' at its upper and lower ends. Said cylindrical casing V surrounds the yoke of the magnet and the armature, and its offsets bear respectively against an insulating-washer b' upon the under side of the annular portion of the magnet and the insulating-washer F′.

A canopy V′ expands over the brush-holder and bears against the top of the outer globe. A cylindrical casing V^2 surrounds the magnet-body and rests with an offset v^2 upon an offset v^3, formed at the upper edge of a flange v^4 of the lower cylindrical casing above the offset v, which bears against the magnet. Said flange v^4 is formed with ventilating-openings v^5, and the upper portion of the upper cylindrical casing has ventilating-openings v^6, so that the magnet and coil may be properly ventilated and thereby kept sufficiently cool. A canopy V^3 has an offset v^7, with which it rests upon the upper edge of the upper cylindrical casing. A cylindrical casing V^4 is secured to the central opening of this canopy and has a funnel-shaped casing V^5 secured to its upper end. A canopy V^6 is secured with its central opening upon the screw-bolt A^2 and overhangs the upper edge of the funnel-shaped casing, a space being formed between the overhanging portion of the canopy and the upper portion of the funnel-shaped casing, in which the switch-handle may have play, as illustrated in Fig. I. The canopy rests upon the nut t^{12}, which secures the switch mechanism and has an insulating-washer v^8 placed against it from above. A small cap V^7 fits upon the bolt against said washer and an eye V^8, having a screw-threaded hole in its periphery, is screwed upon the upper end of the bolt securing said cap, washer, and canopy and serving as a means for suspending the lamp.

In practice the lamp is suspended by its eye and the leads are inserted through the upper canopy and respectively connected to the transverse conductor formed by the ring S and its arms and to the opposite contact-plate of the switch, as illustrated in Fig. III. The lamp is constructed to operate on a constant-potential circuit, and a number of lamps will, consequently, be connected to the main conductors in multiple arc. When the lamp is not burning, the circuit of the lamp is broken, as the connection between the leads through the lamp is interrupted by the contact-bar of the switch being out of contact with the contact-plates. When the current is to be turned into the lamp, the switch-handle is turned so as to bring the end of the segmental slot in the switch-lever to bear against the pin of the arm pivoted to the spring and thereby force said spring open. The moment said pin passes the central line between the fulcrum of the switch-lever and the end of the spring the latter will force the end of the arm against the shoulder of the segmental notch in the contact-bar, throwing the latter over to engage the contact-plates, as illustrated in Figs. III and IX, the pin of the pivoted arm sliding in the segmental slot of the switch-lever without moving the same. The switch is opened by reversing the above-described movement, which will throw the contact-bar out of contact with the contact-plates. When the circuit is closed in the lamp by the switch being closed, the current will pass from the positive lead through the contact-plate T′, the contact-bar and the opposite contact-plate T to the positive conductor, which is secured to said contact-plate. The positive conductor conveys the current through the coil of the magnet, energizing the latter, to the magnet-body and axial tube A, which parts thus form a part of the conductor in the lamp. The current passes through the axial tube to the brushes, which convey the current to the positive electrode, passing between them. From the positive electrode the current forms the arc or directly passes to the negative electrode, from which it passes through the holder for the same and through the rheostat, the negative-electrode support, the negative-conductor disk F, the spring-contact, and the negative conductor, to the transverse conductor S, which conveys the current to the negative lead across the top of the lamp. The arc is formed by the magnet raising the armature and its clutches, whereby the positive electrode is raised. The ring d^5, which retains the clutch-rings, is free to have vertical play upon the armature, and may therefore move up and down with the clutch-rings, so as to insure their correct horizontal alignment, and to control the rings so that they will all clamp the electrode at the same time.

The resistance device of the rheostat is formed from a compound of carbon and some refractory and non-conducting material, such as fire-clay, said material being finely comminuted and intimately mixed, whereupon the tubular body is suitably molded and subsequently dried and baked. As carbon is non-volatile, and the rheostat is exposed to a high degree of heat in the outer arc-inclosing chamber, I prefer to employ carbon as the conducting material in the resistance-body; but if the rheostat is less exposed to heat any other conductor in a finely-comminuted form may be employed in place of the carbon. The proportion of the conductor to the refractory non-conductor may be varied according to the degree of resistance desired. The finely-comminuted conductor, being embedded throughout the refractory and non-conducting mass, will be protected against oxidation by said refractory and non-conducting mass, as air will be mechanically excluded from the conducting particles by the surrounding mass. The resistance-body of the rheostat will consequently not be affected by the heat to which it is exposed by being inclosed within the outer arc-inclosing chamber in a highly heated atmosphere. The rheostat is not liable to be injured by accidental exposure to a current of excessive strength, as its structure is such that it will not be affected by a high temperature caused by such excessive current.

The entire lamp structure is supported from the axial electrode-containing tube and its screw-bolt, the outer casing being also supported from said tube through the lower cylindrical casing, being clamped between the lower end of the magnet and the negative conductor-disk F, which, in its turn, is supported by the nut upon the lower end of the axial tube. This entire construction renders the lamp structure rigid and durable. The top of the outer arc-inclosing chamber is closed air-tight, and no communication can take place with the interior of the lamp structure, excepting through the brush-box and the axial tube. The latter is, however, closed air-tight at its upper end and closed at all other points excepting at the slots through which the clutches project. The chamber surrounding the clutches is closed air-tight by the lower cylindrical casing and its washers, and any communication which might be established through the spaces between the armature and the axial tube and the magnet-tube is cut off by the air-tight fit of said tube to the tubular portion and the upper annular portion of the magnet, and by the air-tight fit of the tubular portion of the magnet upon the axial tube. The bottom of the outer arc-inclosing chamber is closed by a downwardly and outwardly yielding cover O, which acts as a safety-valve to permit of free outlet for the air or gases contained in the outer chamber, so that explosions of the contents of the chamber will be prevented, all expansion of the contents of the chamber being accommodated by free outlet for such contents. The outwardly-flaring flange around the bottom opening of the globe will serve as a water-shed, preventing water from entering the joint between the globe and the yielding cover when the lamp is employed in the open air or wherever it may be exposed to rain, snow, or condensation of moisture upon the surface of the globe. The inner arc-inclosing chamber is closed tight, but not air-tight. The lower end of the globe fits upon its seat in the upper end of the negative-electrode support, and the upper end is partly closed by the cover, the washer in the cover, and the disk having the central tube. When the arc is formed, the air within the inner arc-inclosing chamber becomes rarefied or expanded, and the heated surplus is discharged into the outer chamber, where, by virtue of its great levity, it finds its level in the uppermost portion of said chamber, displacing a corresponding volume of cold air through the outwardly-yielding closure in the bottom of the outer chamber. The product of combustion of the carbon and oxygen in the inner arc-inclosing chamber is CO_2 (carbon binoxide), which subsequently becomes CO (carbon monoxide). This gas, together with the highly-expanded nitrogen of the decomposed air, protects the carbon-points from rapid combustion. Fluctuations of the current and potential in the circuit will cause fluctuations in the temperature of the arc and consequently expansion and contraction of the heated contents of the inner arc-inclosing chamber, and a consequent outflow and inflow of gases out of and into the same. As this process continues, the outer chamber becomes filled with hot, chemically-inert gases, which seek a higher level on account of their levity, and exclude the heavier cold air which escapes through the outlet provided in the bottom of the outer chamber by the outwardly-yielding closure. Finally, these inert gases (chiefly nitrogen) surround the inner arc-inclosing chamber, so that subseqent readjustment of pressure between the two arc-inclosing chambers takes place between these chemically-inert gases, to the more or less perfect exclusion of oxygen, which can only gain access to the outer chamber by a very slow process of diffusion through a very limited inlet. The incident fluctuations of current or potential in the circuit cause expansion and contraction of the contents of the inner arc-inclosing chamber and consequent outflow and inflow of gases out of and into said chambers. Such disturbances tend to adjust themselves in the direction of the least resistance, which in this lamp is at the top of the inner chamber, where the opening presents less obstruction to fluctuations in the gaseous contents on account of the passage for the electrode than at the bottom where the globe rests flat upon its seat. Consequently, the adjustment of the gaseous contents of the chambers will principally take place at the top of the chambers where the more highly-heated and consequently more inert gases are located, which are nearly if not entirely free from oxygen.

From the foregoing it will be understood that the object of the outer globe is not merely to protect the inner and arc-inclosing globe, but to furnish a reservoir or envelope of inert gases which surrounds the arc-inclosing globe and excludes the admission of oxygen thereto and to the arc burning within it.

The arc-inclosing globe must be so constructed as to allow of the free and unobstructed movement and adjustment of the feeding-carbon. This is essential to the production and maintenance of an arc of uniform brilliancy and length. The regulating mechanism of an arc lamp is at all times in action, serving to raise or lower the feeding-carbon ever so little as may be necessary to compensate for fluctuations of current strength and slight imperfections in the carbons, and to feed the carbons by insensible degrees to compensate for their gradual consumption in burning. Hence it is obvious that unless some provision is made for practically excluding the outer air and moisture from the arc-inclosing globe, such an amount of oxygen would find ingress through the opening provided of necessity through or into the globe for the free adjustment and action of the feeding-carbon, as would result in the rapid oxidation and consumption of the carbons. In my improved lamp the outer air and moisture is practically excluded from the arc-inclosing globe by means of the intervening reservoir or envelope of inert gases which surround and protect such inner globe. This outer and surrounding envelope of inert gases is maintained by making or connecting the outer globe in such a manner as that it will exclude moisture therefrom and prevent any appreciable upward draft of air through it.

If openings of any considerable size were formed or permitted to exist in both the top and bottom of the outer globe the latter would serve as a chimney and cause an upward draft of air through it, which would operate to drive out such a portion of the gases generated by the arc and admit such a quantity of oxygen as would result in a comparatively-rapid oxidation and consumption of the carbon-electrodes.

While I have shown and described one form of construction of inner and outer globe by which an upward draft of air through the space between them is prevented and by which moisture is excluded, I do not restrict myself to the particular construction and arrangement of parts shown and described.

If desired, tubular carbons having a very thin wall may be used in lieu of the ordinary solid carbon. When tubular carbons are used in my improved lamp, the arc will travel around the lower edge of the carbon, but such travel of the arc will not affect the steadiness or the uniformity of the light to any perceptible degree as the arc is considerably longer than the arc of an ordinary arc lamp, and the radiation of light is consequently not materially obstructed by the carbons. To show the difference between the illuminating actions of solid carbons as used in the ordinary arc lamps, and of a tubular positive carbon in my improved lamp, Figs. X and XI respectively illustrate the ends of such carbons with the lines of radiation indicated by dotted lines. It will be observed that the arc of my improved lamp is considerably longer than the arc of an ordinary lamp, and this abnormally-long arc is maintained by reason of its being inclosed within and protected by the comparatively air-tight arc-inclosing globe. By increasing the length of the arc its resistance will be increased, with the result that it will require an increased voltage of the current to maintain it. The arc of a lamp in which no provision is made for excluding the outer air from the burning carbons ordinarily requires a current of from forty-five to fifty volts, and hence when such lamps are used on an ordinary incandescent lamp-circuit usually employing about one hundred and ten volts, a resistance must be included in series with the lamp in the multiple-arc branch across the mains to reduce the current through the lamp, although the employment of such a resistance involves a useless expenditure of current energy. Now by employing arc lamps capable of maintaining a long arc of high voltage, the resistance in the circuit may be correspondingly reduced. If the conditions are such that a lamp may be operated with an arc requiring a current of one hundred and ten volts to maintain it, then any such added resistance in the same multiple-arc branch circuit may be altogether dispensed with, and if the conditions are such that it is impossible to maintain an arc of a length sufficient to require a current of more than, say, eighty volts, then a resistance should be included in series with the lamp for consuming the other twenty-five volts.

The carbon-sheath and the washer in the cover for the inner arc-inclosing chamber serve as a cut-out for the lamp. When the positive carbon has been consumed to such an extent that the lower end of the carbon-sheath reaches said washer, the sheath will be stopped, as the opening of the washer is of just sufficient size to pass the carbon while it stops the sheath. The arc will, consequently, gradually increase in length, as the carbons are consumed, until the distance between the ends of the carbons becomes too great for the maintenance of the arc, when the latter will break, and the path for the current through the lamp will be obstructed.

When the lamp is to be trimmed, the insulating-handle is grasped and the negative electrode-holder with its rheostat is turned so as to bring the lugs upon the casing of the latter to register with the notches in the rheostat-supporting ring of the electrode-supporting frame. The entire carbon-holder, rheostat, and inner globe may then be removed, the ring of the supporting-frame being of such diameter that the inner globe will easily pass through it. The upper carbon and sheath slips down with the globe, being supported in the tube upon the cover of the same. When the holder, rheostat, and inner globe are detached, the interior of the outer globe may be cleaned by inserting the hand with a cloth through the bottom opening of the globe. The inner globe may be cleaned and a new carbon inserted in the negative-carbon holder. A new positive carbon may be inserted in the sheath and thereupon inserted from above through the tube in the cover of the inner globe. The carbon-holder, rheostat, and globe may now be again inserted into the outer globe, the carbon-sheath and upper carbon being pushed up between the brushes by the lower carbon. When the long lugs of the rheostat strike the ring, the carbon-holding structure may be turned and again locked in place. As the vertical diameter of the outer globes may vary, the carbon-holder is adjustably secured in the rheostat—the set-screw m' providing such adjustability—so that the carbon-holder may be adjusted to bring the yielding cover to a proper fit in the flaring flange of the globe, when the rheostat is in its properly secured position in the ring of the carbon-supporting frame.

By the term "carbon-holding" structure the entire detachable structure is meant, viz: the carbon-holder, cover, and rheostat.

Other modes of applying the principle of my invention may be employed for the mode herein explained. Change may therefore be made as regards the mechanism thus disclosed, provided the principles of construction set forth respectively in the following claims are employed.

I therefore particularly point out and distinctly claim as my invention—

1. In the art of arc-electric lighting, the method of protecting the arc and prolonging the life of the electrodes which consists in surrounding the arc by an inclosed body of chemically inert gases, and surrounding such inclosure by an envelope or inclosed outer reservoir of chemically inert gases, said inner and outer inclosed bodies communicating with one another.

2. In an arc-electric lamp the combination with an arc-inclosing globe, of an outer globe or chamber, said globes being constructed and arranged to insure and maintain an envelope or reservoir of chemically inert gases around and in communication with the body of gas in the arc-inclosing globe substantially as set forth.

3. In an arc electric-lamp, the combination with an arc-inclosing globe, of an outer globe or chamber constructed to insure and maintain an envelope or reservoir of chemically inert gases around and in communication with the body of gas in the arc-inclosing globe and provided with an outwardly yielding closure, substantially as set forth.

4. In an arc electric-lamp the combination with an arc-inclosing globe, of an outer globe or chamber constructed to insure and maintain an envelope or reservoir of chemically inert gases around and in communication with the body of gas in the arc-inclosing globe the outer globe or chamber being provided with a detachable portion with which is connected the lower electrode holder, substantially as set forth.

5. In an arc-electric lamp the combination

with an arc-inclosing globe, and an outer globe or chamber, of a lower electrode-holder detachably secured to a support rigidly connected with the lamp frame, and an outwardly yielding valve, connected with the lower electrode holder, substantially as set forth.

6. In an electric-lamp the combination with that portion of the lamp structure inclosing the feeding mechanism, of a lower electrode supporting frame, a globe surrounding the frame and secured thereto, the latter being detachably secured to the lamp structure outside of the globe, substantially as set forth.

7. In an electric lamp the combination with that portion of the lamp structure in which the regulating mechanism is contained, of a lower electrode supporting frame an outer globe and an arc inclosing globe both connected with said frame, the latter being provided with a connection outside of the globe whereby it is detachably secured to the upper portion of the lamp structure, substantially as set forth.

8. In an electric lamp, the combination with a lower electrode supporting frame formed with an opening at its lower end, of an electrode holding structure having means for locking it in said opening, and an arc inclosure supported upon said structure and of such diameter that it may be inserted through the opening of the frame, substantially as set forth.

9. In an electric lamp, the combination with a globe having an opening at its bottom and a lower electrode supporting frame within said globe and formed with an opening at its lower end registering with the bottom opening of the globe, of an electrode holding structure having means for locking it in the opening of the frame, and an arc inclosure upon said structure and of such diameter that it may be inserted through the opening of the frame, substantially as set forth.

10. In an electric lamp, the combination of a globe having an opening at its bottom, a lower electrode supporting frame within said globe and formed with an opening at its lower end registering with the bottom opening of the globe, an electrode holding structure having means for locking it in the opening of the frame, an arc inclosure supported upon the upper end of the electrode holding structure and of such diameter that it may be inserted through the opening of the frame, and a cover which fits in the bottom opening of the globe and is secured outwardly yielding upon the lower end of the electrode holding structure, substantially as set forth.

11. In an electric lamp, the combination of a lower electrode supporting frame having a horizontal ring at its lower end formed with notches in its interior periphery, and a lower carbon holding structure provided with lugs which register with and may pass through the notches in the ring and rest upon the upper edge of the same when the structure is partly rotated in the ring, substantially as set forth.

12. In an electric lamp, the combination of a lower electrode supporting frame having a horizontal ring at its lower end formed with notches in its interior periphery, and a lower carbon holding structure provided with upper lugs which register with and pass through the notches in the ring and rest upon the upper edge of the same when the structure is partly rotated in the ring and with lower lugs which cannot pass through the notches and bear against the lower edge of the ring, substantially as set forth.

13. In an electric lamp, the combination of a lower electrode supporting frame formed with an opening at its lower end, a globe surrounding said frame and formed with a bottom opening, a lower electrode holder, a cover for the bottom opening of the globe and supported upon said holder, and a part adjustably secured upon the holder and provided with means for locking it in the opening of the supporting frame, substantially as set forth.

14. In an electric lamp, the combination of an arc inclosing chamber, an electrode supporting frame within said globe and forming a part of one lamp terminal and formed with a ring at its lower end, a tubular rheostat having means for securing it in said ring and having one of its terminals in contact with the frame and an electrode holder secured in the rheostat and in contact with its other terminal, substantially as set forth.

15. In an electric lamp the combination with the lower electrode holder and a supporting frame, of a rheostat interposed between the electrode holder and supporting frame, said rheostat comprising an inner and an outer casing and an intervening resistance material, substantially as set forth.

16. A rheostat consisting of an axial tube, a casing attached to but insulated from said tube, an annular cylinder essentially composed of a refractory and non-conducting substance and a finely comminuted conductor in intimate commixture therewith and interposed between but insulated from the tube and casing but in electrical contact with one end of the casing, an annular disk upon the opposite end of the tube and having a central hub in contact with the resistance cylinder, and contact screws in said disk and capable of being brought into contact with the end of the resistance cylinder, substantially as set forth.

17. In an arc electric lamp the combination with an arc inclosing globe of a cap provided with a tube and a floor, and a washer seated upon the floor and having a lateral adjustment thereon, substantially as set forth.

18. In an electric lamp the combination with a globe having an opening formed in its lower end and an outwardly flaring depending flange

encircling said opening, of a cover provided with a correspondingly outwardly flared edge or rim which seats upon the depending outwardly flaring flange on the globe, substantially as set forth.

19. In an electric lamp, the combination of an armature formed with an axial passage through it and with longitudinal and radial slots into such passage, a ring having longitudinal play upon said armature, clutch rings having play with and upon said ring in the slots of the armature, and inclined surfaces secured to the armature and against which the outer edges of the clutch rings may bear, substantially as set forth.

20. The combination with a pivoted switch contact bar provided with opposing shoulders; a spring and an actuating link pivoted at one end on the spring while the free end engages the contact bar, of an actuating lever constructed to engage the actuating link and move its free end to the opposite sides of its dead center substantially as set forth.

21. The combination with a pivoted switch contact bar provided at one edge with a segmental bearing having shoulders at its opposite ends, and an actuating lever also provided with a segmental bearing having shoulders at its opposite ends, of a pivoted actuating link the free end of which engages the said segmental bearings on the switch contact bar and the actuating lever, substantially as set forth.

22. The combination with a pivoted switch contact bar provided on its edge with a segmental bearing having shoulders at its opposite ends, and an actuating lever pivoted concentrically with the switch contact bar and provided with a similar bearing and shoulders, of a pivoted actuating link or bar, a spring for imparting an endwise movement to the actuating link or bar in any of its adjustments and serving to positively move the contact bar to its open or closed positions, substantially as set forth.

23. In an arc-electric lamp the combination with an arc-inclosing globe, of an outer globe or chamber fitted air-tight at its upper end to the lamp, said globes being constructed and arranged to insure and maintain an envelope or reservoir of chemically inert gases around and in communication with the body of gas in the arc-inclosing globe, substantially as set forth.

In testimony that I claim the foregoing to be my invention I have hereunto set my hand this 15th day of December, A. D. 1891.

WILLIAM JANDUS.

Witnesses:
WM. SECHER,
DAVID T. DAVIES.