No. 724,366. PATENTED MAR. 31, 1903.

J. J. WOOD.

ELECTRIC ARC LAMP.

APPLICATION FILED MAR. 19, 1902.

NO MODEL. 4 SHEETS—SHEET 1.

FIG. 1.

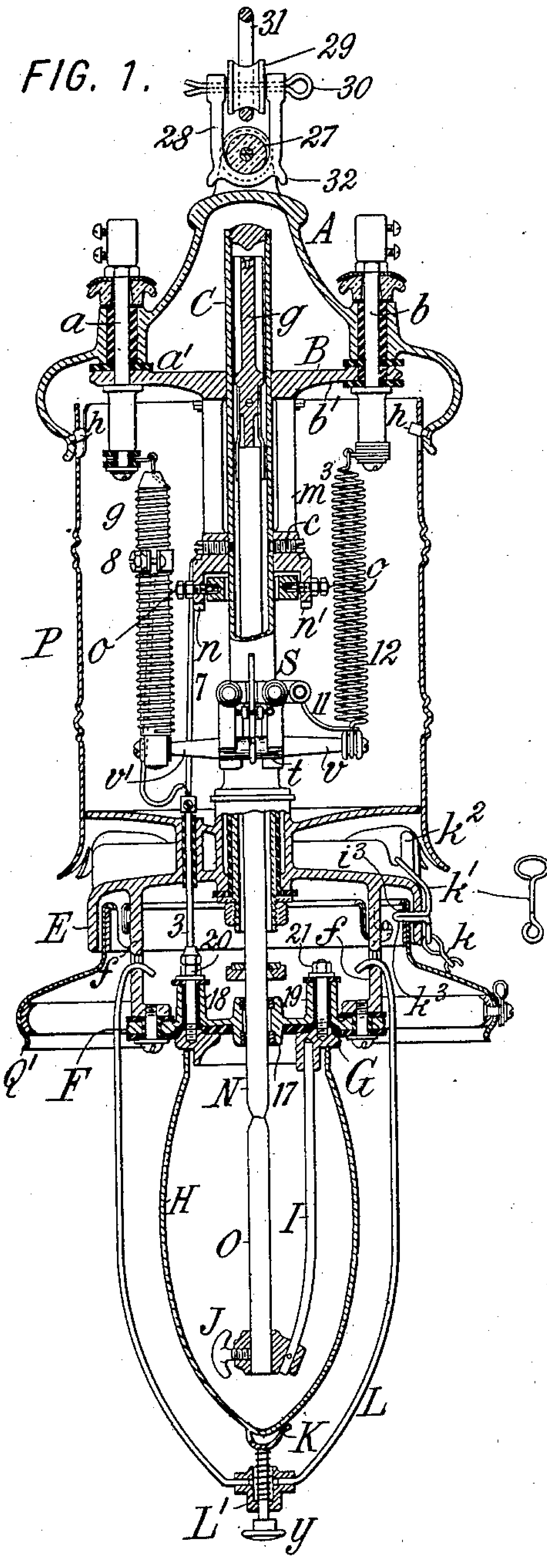
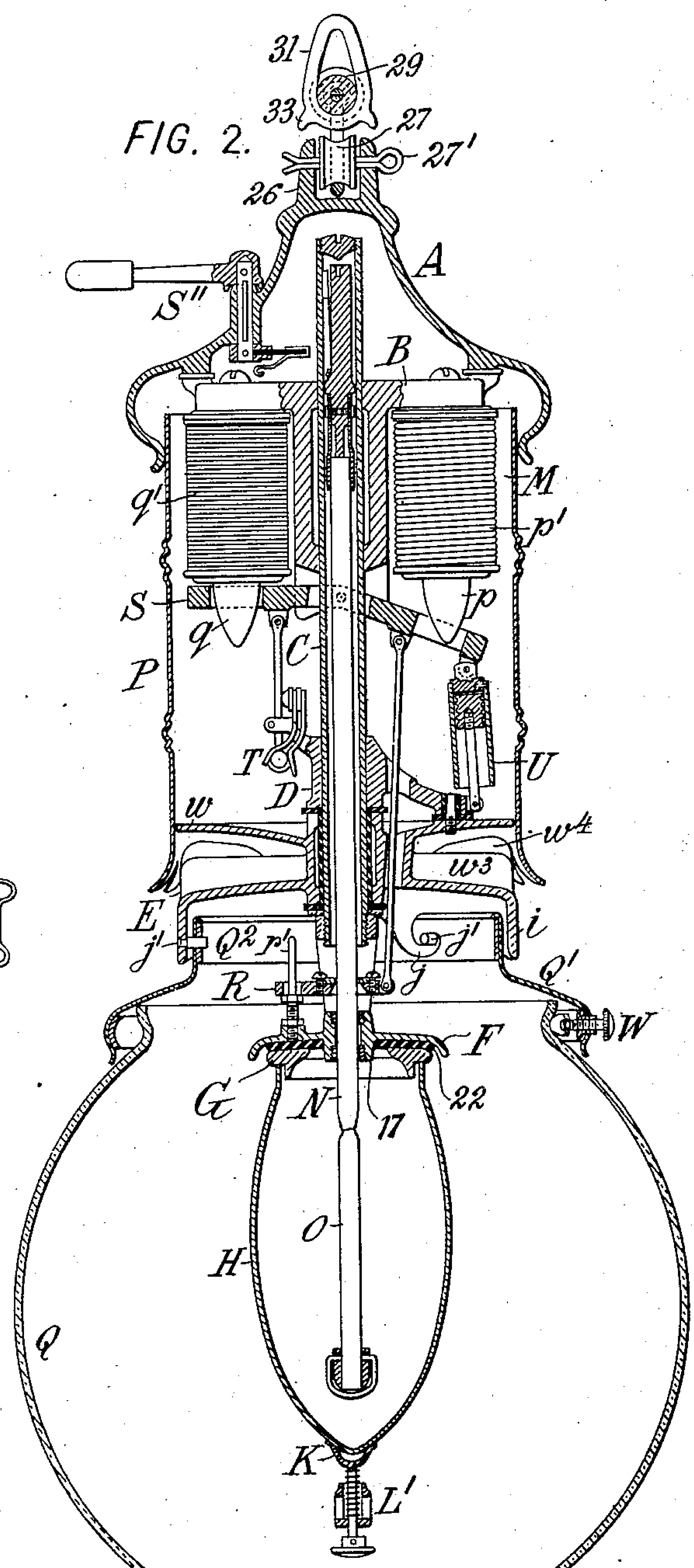


FIG. 2.



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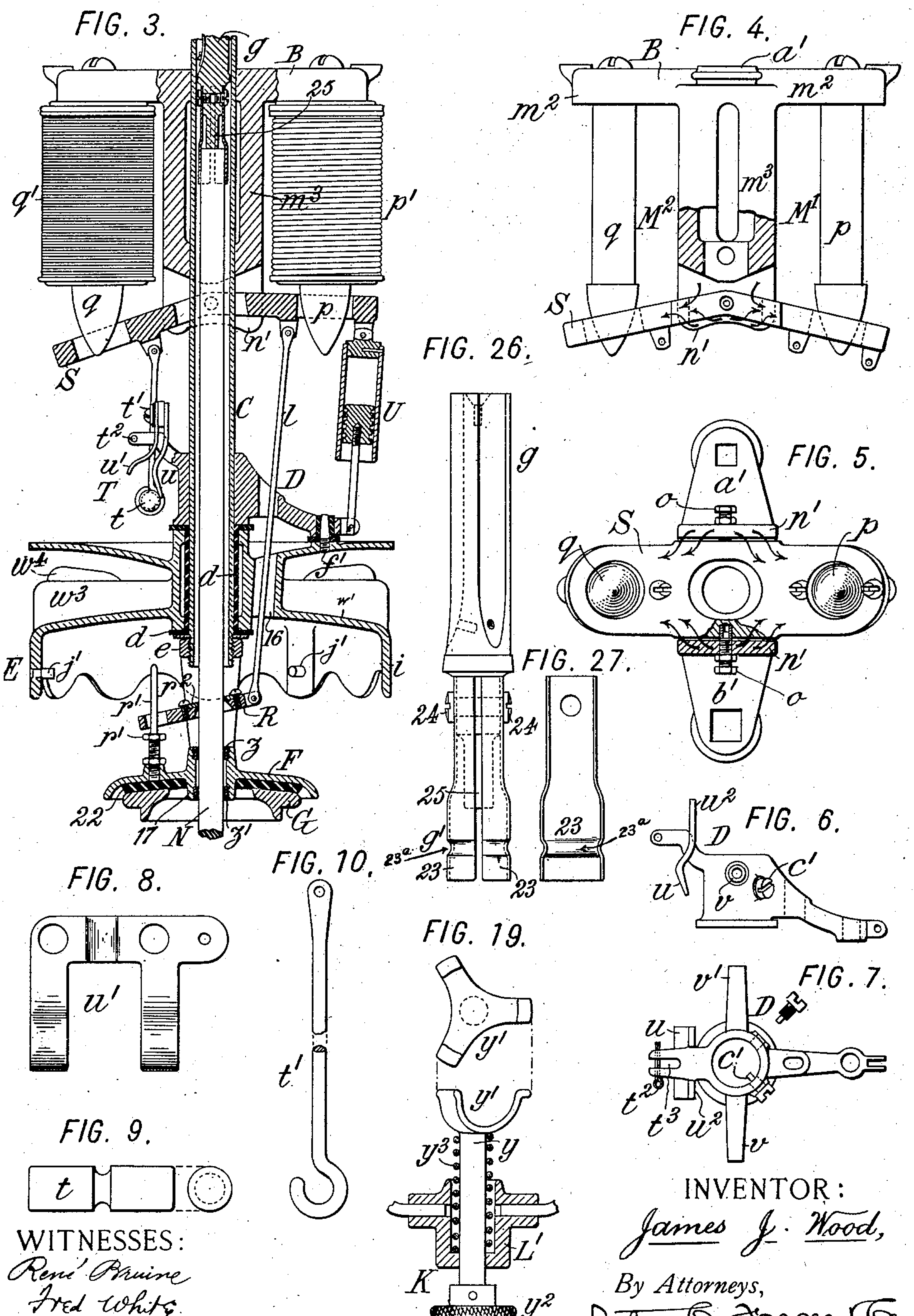
NO MODEL. 4 SHEETS—SHEET 2.



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NO MODEL. 4 SHEETS—SHEET 3.

FIG. 11.

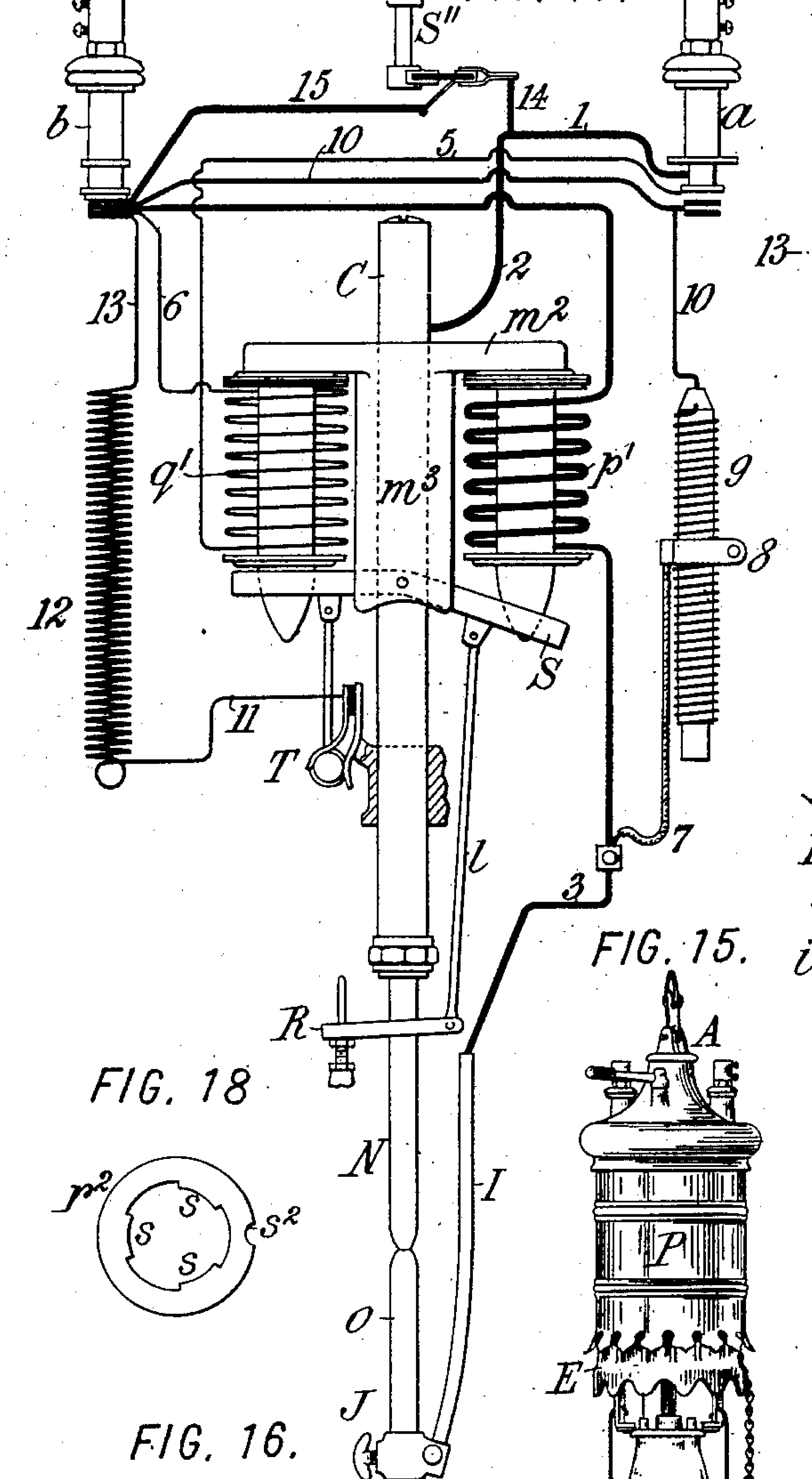


FIG. 12.

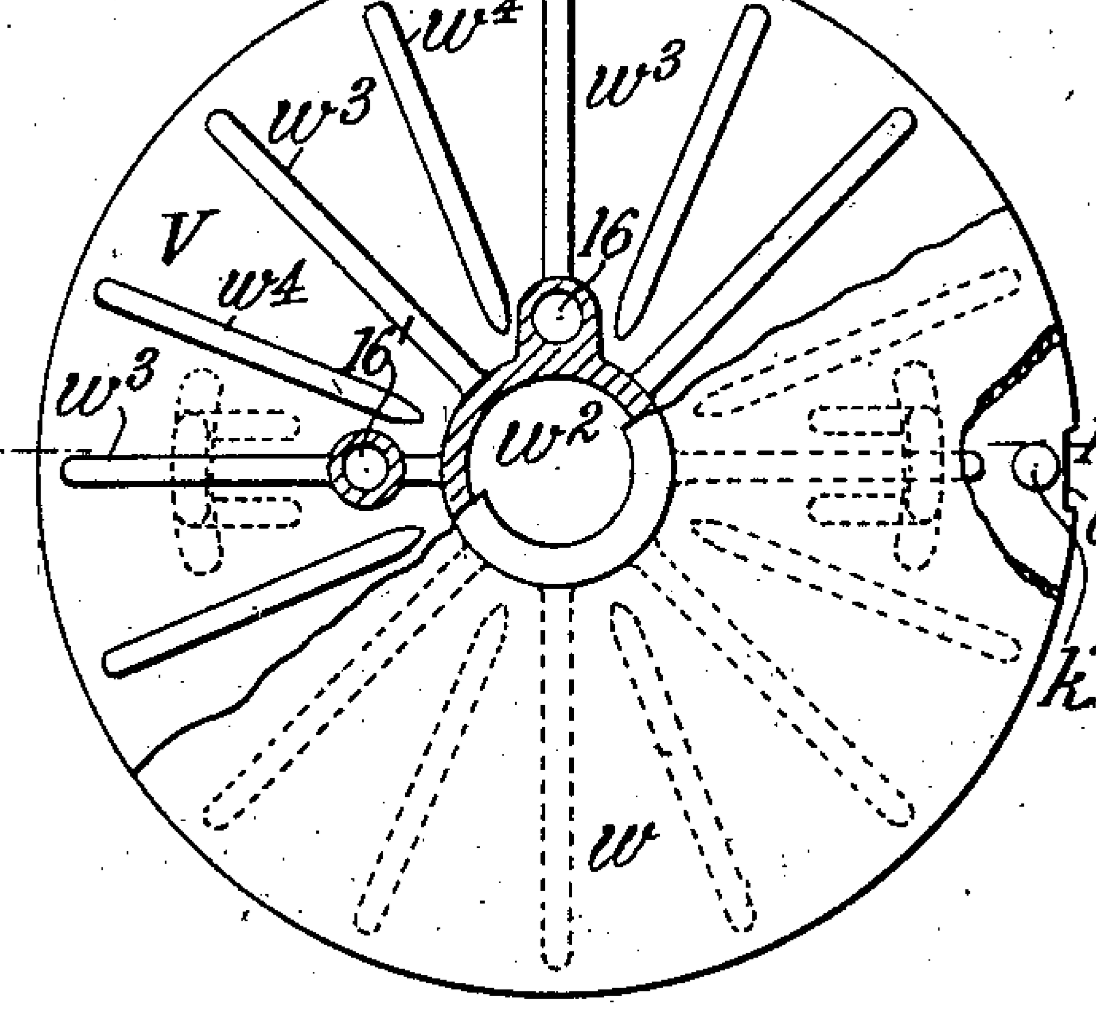


FIG. 13.

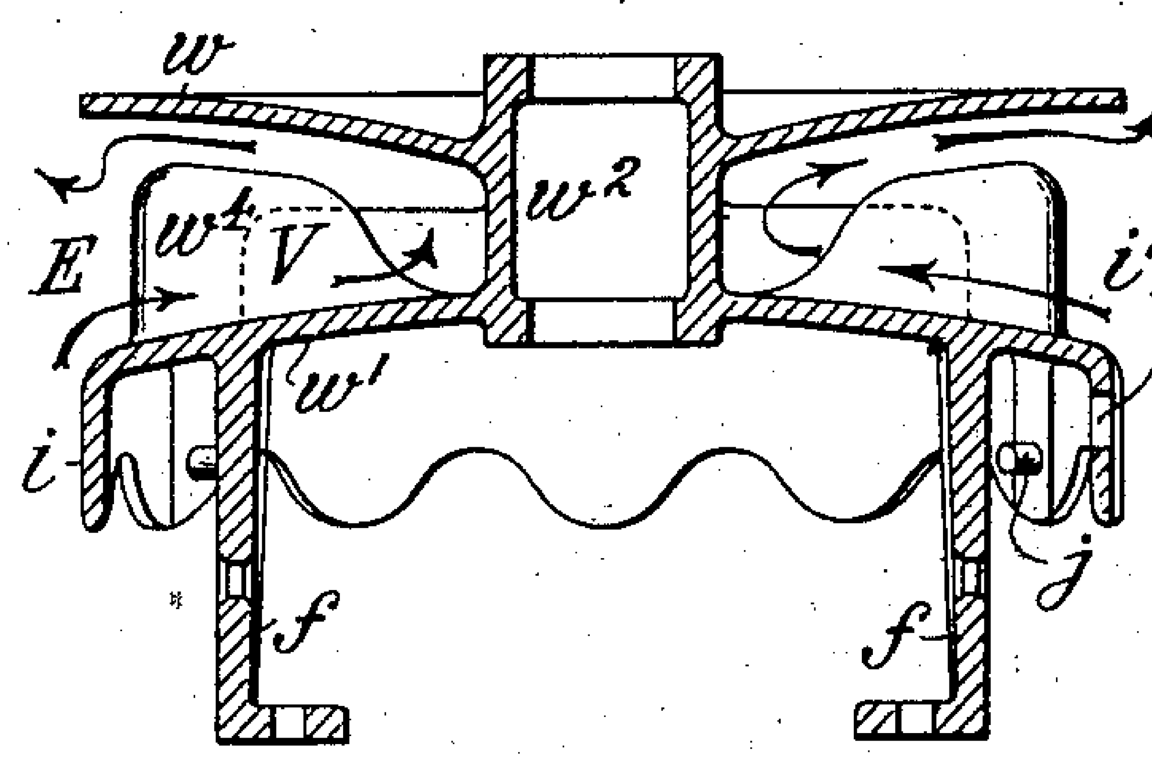


FIG. 14.

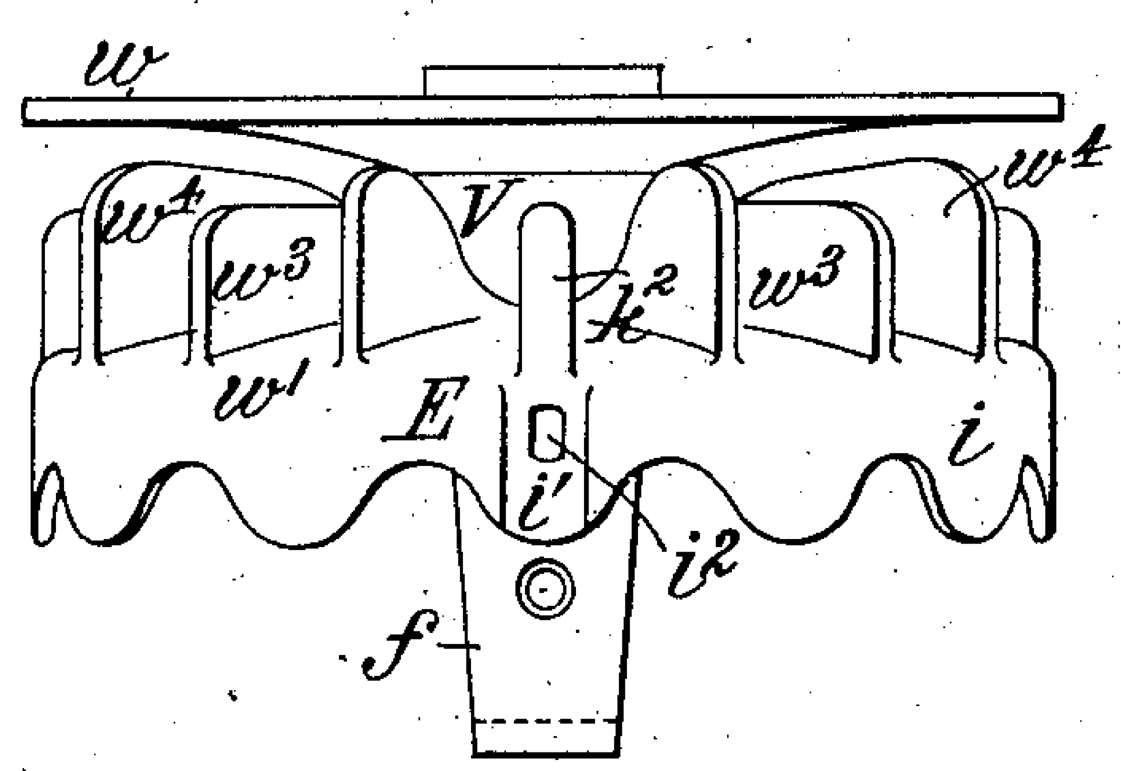


FIG. 15.

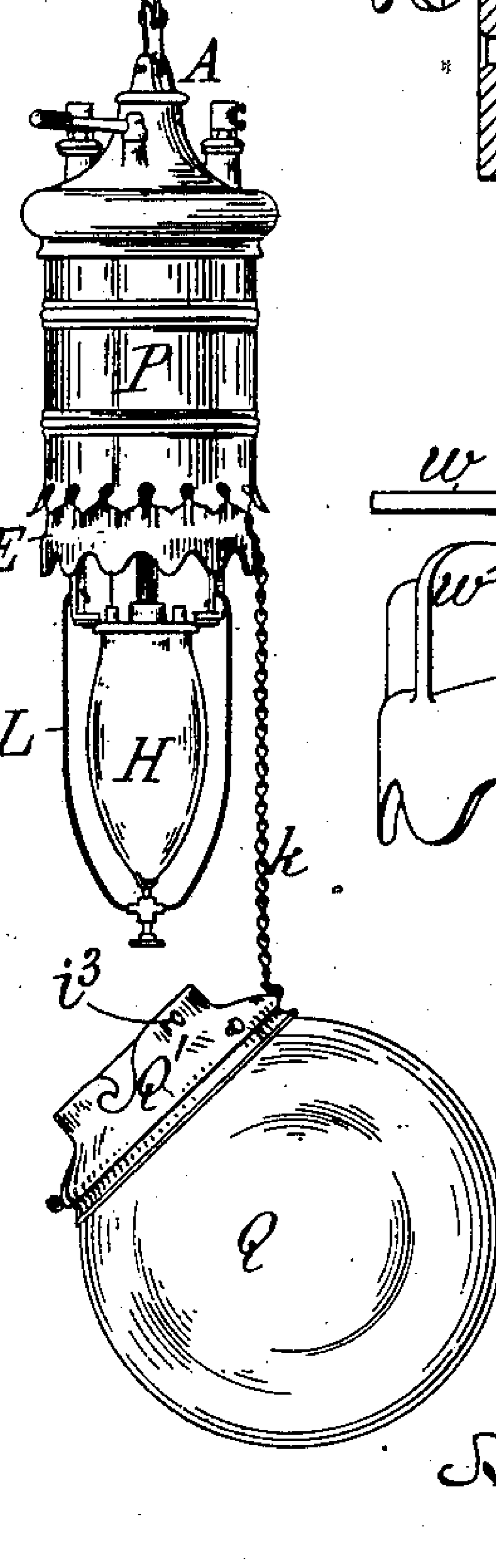


FIG. 18

FIG. 16.

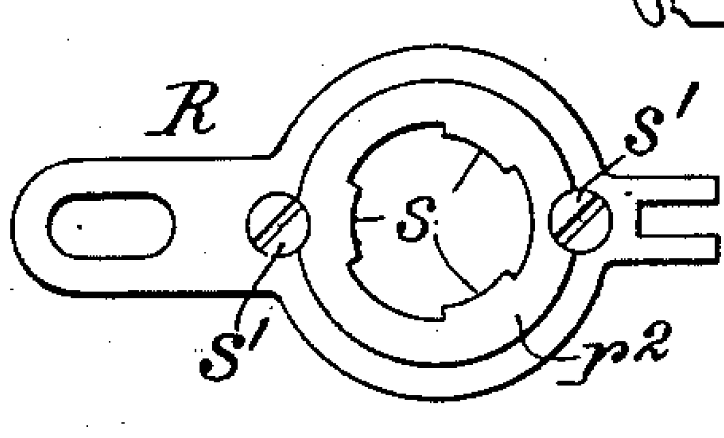
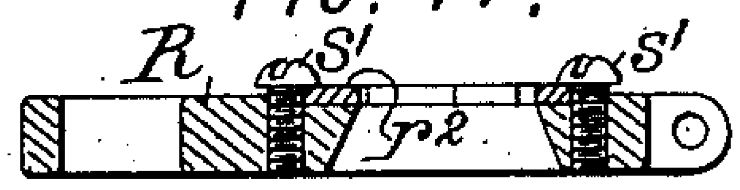


FIG. 17.



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ELECTRIC ARC LAMP.

APPLICATION FILED MAR. 19, 1902.

NO MODEL.

4 SHEETS—SHEET 4.

FIG. 20.

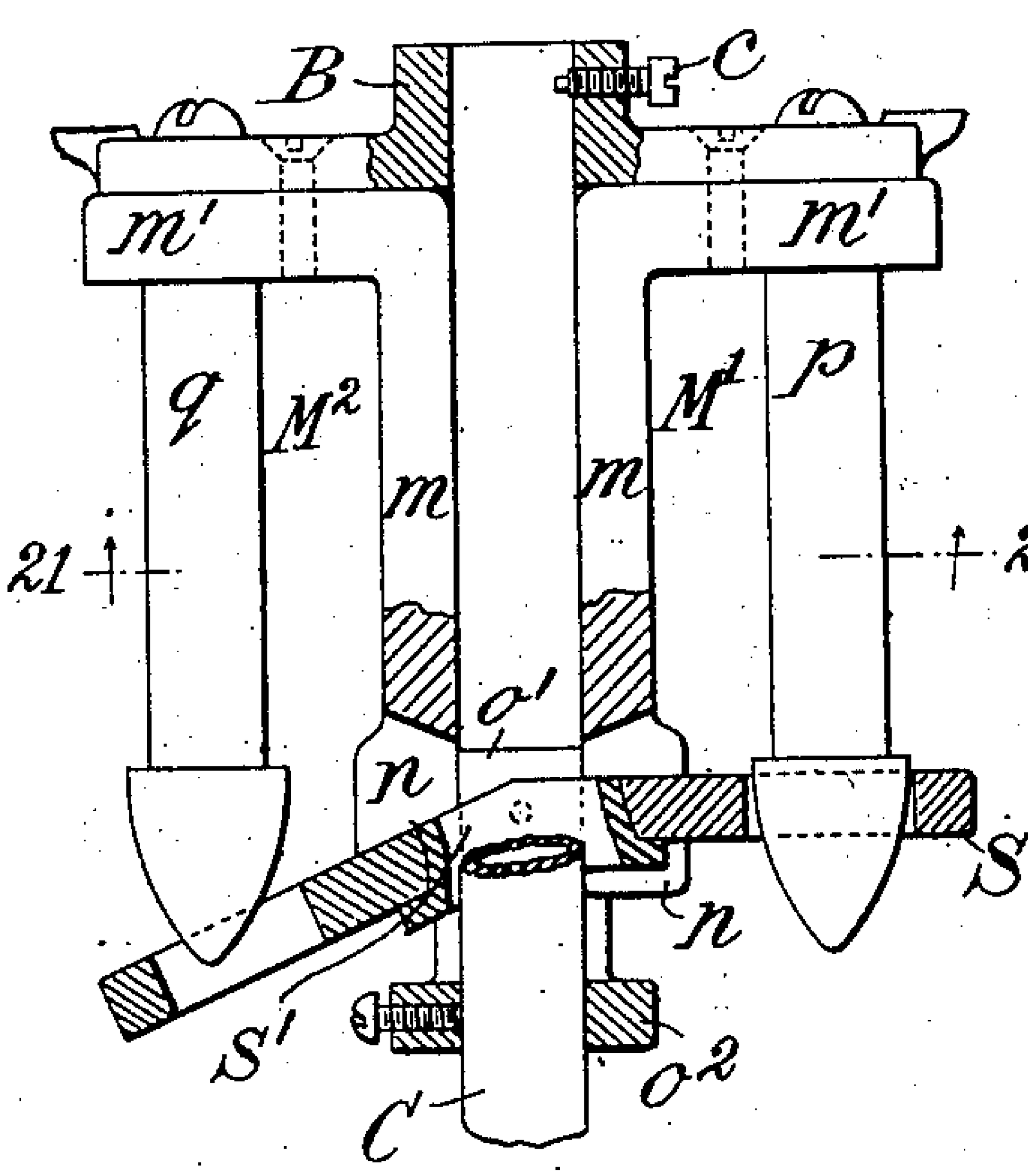


FIG. 23.

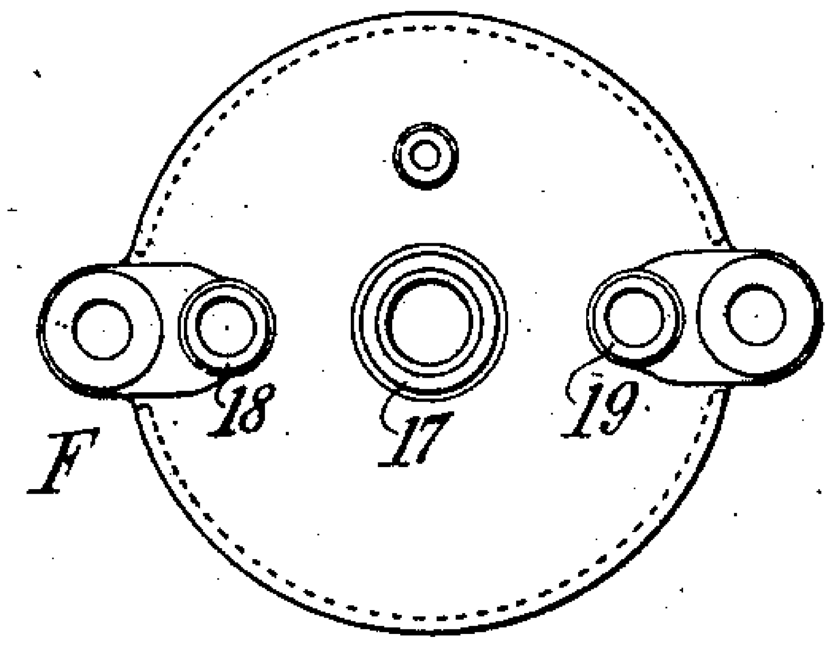


FIG. 24.

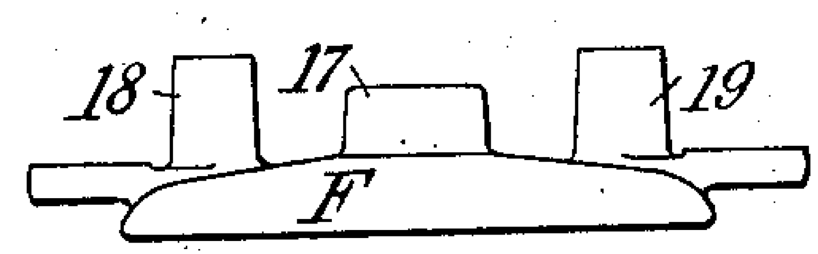


FIG. 21.

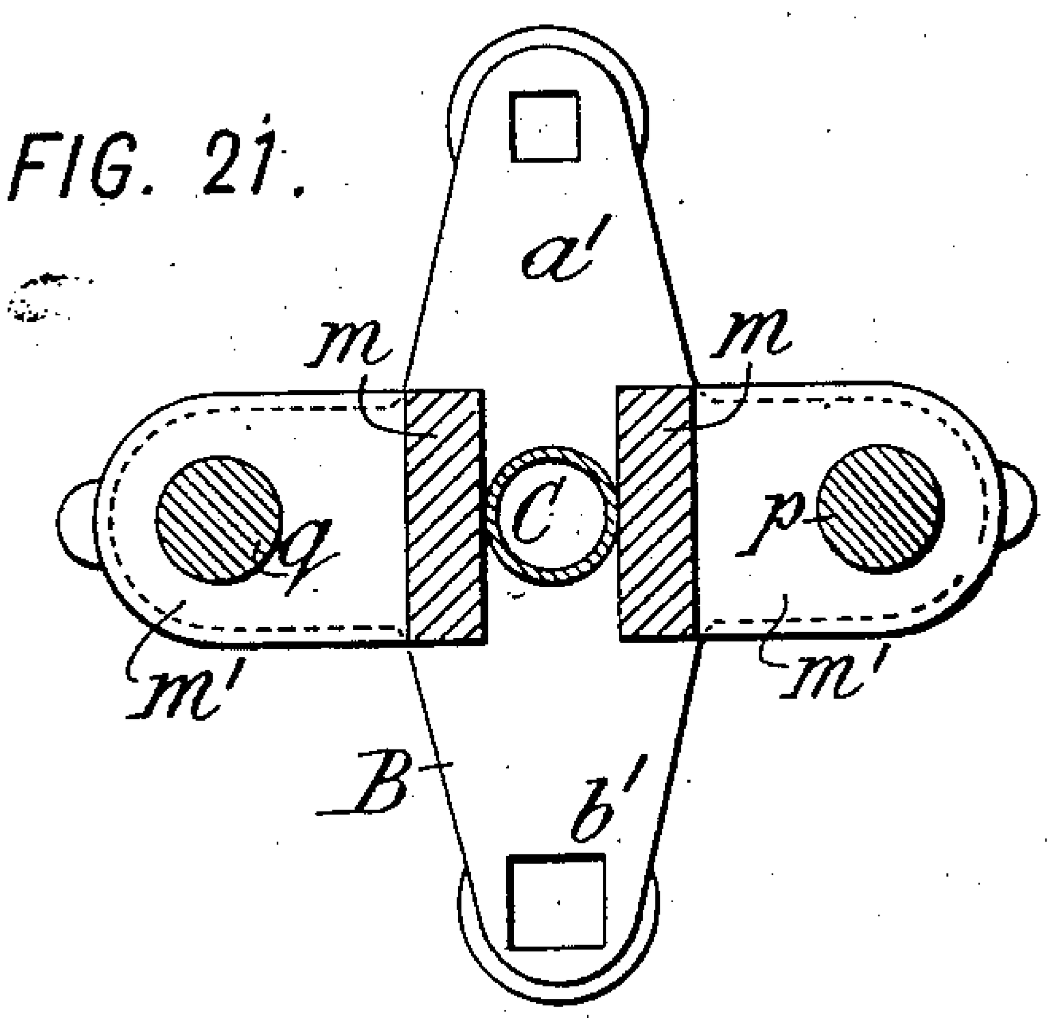


FIG. 25.

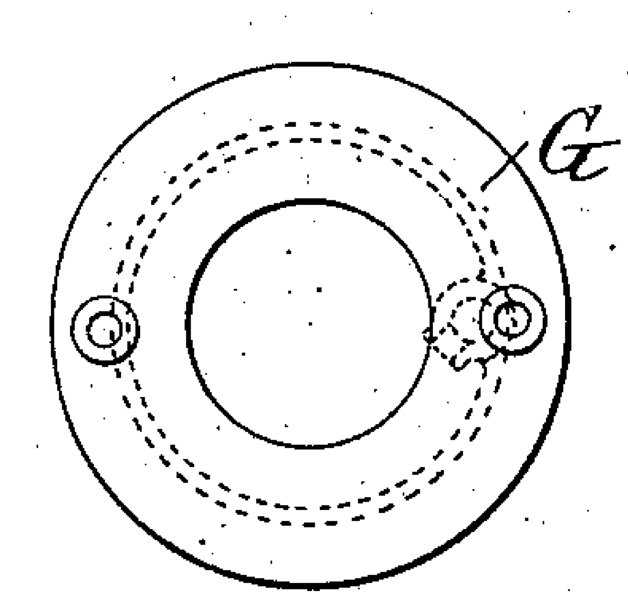
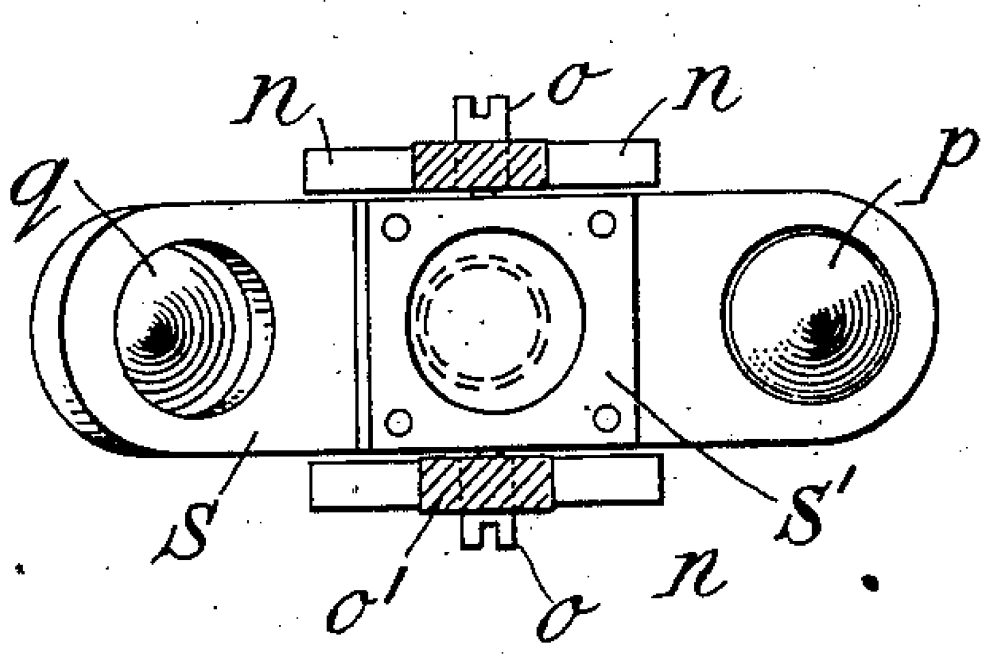


FIG. 22.



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Fred White

UNITED STATES PATENT OFFICE.

JAMES J. WOOD, OF FORT WAYNE, INDIANA.

ELECTRIC-ARC LAMP.

SPECIFICATION forming part of Letters Patent No. 724,366, dated March 31, 1903.

Application filed March 19, 1902. Serial No. 98,984. (No model.)

To all whom it may concern:

Be it known that I, JAMES J. WOOD, a citizen of the United States, residing at Fort Wayne, in the county of Allen and State of Indiana, have invented certain new and useful Improvements in Electric-Arc Lamps, of which the following is a specification.

This invention provides certain improvements in electric-arc lamps designed chiefly for use on constant-current circuits, but adaptable also to other uses.

The invention relates in part to a differential regulating-magnet, in part to an improved automatic cut-out, in part to means especially applicable in an inclosed-arc lamp for preventing overheating of the mechanism, in part to an improved clutch, and also to various other features and details of construction.

The accompanying drawings show my improved lamp in its preferred form where my invention is embodied as an inclosed-arc carbon-feed lamp for use on constant-current series circuits.

Figures 1 and 2 are vertical mid-sections in planes at right angles to one another and showing the lamp inactive, the outer globe being omitted in Fig. 1. Fig. 3 is a section of the operative parts, on a larger scale, showing the lamp in operation, the mechanism-case being omitted. Fig. 4 is a sectional elevation of the magnet with its coils removed. Fig. 5 is an inverted plan thereof, partly in section. Fig. 6 is a side view, and Fig. 7 a plan, of a bracket which supports the cut-out and dash-pot. Fig. 8 is a front view (compare Fig. 1) of one of the cut-out terminals. Fig. 9 is a side and end view of the circuit-closing roller for the cut-out. Fig. 10 is a side view of the link which carries this roller. Fig. 11 is a circuit diagram. Fig. 12 is a plan of the heat-radiator, partly in section. Fig. 13 is a transverse section thereof cut on the lines 13 13 in Fig. 12. Fig. 14 is a side elevation thereof. Fig. 15 is an elevation of the entire lamp, on a small scale, with its outer globe lowered. Fig. 16 is a plan, and Fig. 17 a longitudinal section, of the carbon-clutch. Fig. 18 shows the clutch-ring removed. Fig. 19 is a sectional detail of the spring-holder for the inner globe. Figs. 20, 21, and 22 show a modified differential magnet. Figs. 23, 24, and 25 show the parts of the gas-cap. Fig. 26 is an elevation of the carbon carrier and holder, Fig. 27 showing one of the springs thereof.

I will proceed to describe the construction of the lamp thus illustrated as embodying my invention.

In its mechanical construction the lamp comprises a hood A, adapted for suspension in the usual manner, beneath which is fastened, preferably by means of the binding-posts *a b*, Fig. 1, a plate or casting B, which supports (and may form part of) the core of the differential regulating-magnet M. Centrally within this plate B is fastened a vertical tube C, which affords the sole mechanical support for the parts beneath and through which travels the upper carbon. A bracket or casting D is fastened upon the tube C considerably below the magnet. The castings B and D are firmly fastened to the tube by screws or pins *c c'*, so that they are rigidly connected together through the tube. Upon the lower end of the tube, directly beneath the bracket D, is fastened another casting E, which I shall term a "heat-radiator." This is preferably insulated from the tube and from the bracket D by an intervening insulating-bushing *d*, Fig. 3, and is clamped in place by a nut *e*, screwing on the lower end of the tube. To keep it from turning on the tube, it is provided with a pin *f*, which projects up through the hole in an arm on the bracket D, Fig. 3, this pin being separated from the bracket by intervening insulation.

The radiator E supports beneath it a cross head or plate F, forming part of the gas-cap for closing the top of the inner globe H. The plate F preferably serves as the mechanical support for the arm I, which carries on its lower end the lower carbon-holder J. In the construction shown the arm I is connected directly and electrically to a gas-ring G, which is insulated from the cross-head F. The cross-head F is shown as supported by being clamped to the lower ends of pendent arms *f f*, Fig. 1, cast integrally with the radiator E. The inner globe H is supported by a spring-clamp K at its lower end, which clamp is hung on a swinging bail L, formed of wire rods, the upper ends of which are formed so as to hook into holes in the arms *f f*. (See Fig. 1.)

N and O are respectively the upper and lower carbons. The lower carbon is held in the holder J, as usual, while the upper one passes up into the tube C and is engaged at its upper end by any suitable kind of carrier or trolley g, (the trolley shown being of the general construction set forth in my Patent No. 678,607, granted July 16, 1901,) or may be connected in any other way to the appropriate circuit-terminal.

The lamp is provided with a cylindrical casing P, which incloses the space between the upper hood A and the lower casting or radiator E, which inclosed space constitutes the mechanism-case. The casing P is preferably of sheet metal and is preferably removable by being displaced downwardly, to admit of which the radiator-casting E is made of slightly-smaller external diameter than the internal diameter of the casing. The upper end of the casing projects up within the downturned flange of the hood A and is fastened in place by angular slots or bayonet-joints engaging pins h within this flange.

For supporting the outer globe Q its neck or upper flange is engaged in an annular hood or holder Q′, preferably of sheet metal, the upper part of which is contracted to form a neck Q^2, which projects up within a downwardly-projecting flange i on the radiator-casting E. To provide an easily-detachable connection, the neck Q^2 is formed with angular or bayonet slots j, engaging pins j', projecting inwardly from the flange i. To disconnect the outer globe, it is only necessary to lift and slightly turn the globe and its holder Q′, whereupon they may be lowered until they hang suspended by a chain k, as shown in Fig. 15. The casing P may then be similarly disconnected and lowered. The globe Q is attached to the holder Q′ in any known way—as, for example, by set-screws, of which one is shown at W in Fig. 2.

These several features of mechanical construction, to which, however, my invention is not limited, being now understood, I will proceed to describe those features of my invention which constitute its most important and essential portions.

The carbon-clutch R, which is located beneath the radiator E, is connected in a simple manner by a single link or connecting-rod l directly to the armature S of the regulating-magnet M. The regulating-magnet is of novel construction. It involves, essentially, two magnets or magnetic circuits, which may be wholly distinct or may have one core or frame in common, the respective magnets or magnetic circuits being excited by series and shunt coils to attract differentially the opposite arms of a tilting lever constituting or formed with the armature or armatures of the respective magnets. This armature-lever or lever-armature is pivoted intermediate of its ends, so that its respective end portions are arranged in proximity to the pole-pieces of the cores or portions of the magnetic system which are wound with the respective coils, and its intermediate portion is so connected magnetically as to complete the two magnetic circuits which include the respective cores within the coils and the respective arms of the armature or armature-lever. The magnetic connection is so made as to distribute the magnetic flux from the fixed magnet to the armature in such manner that the middle or pivotal portion of the latter shall be approximately in magnetic equilibrium. To this end the magnetic flux is directed laterally into the pivotal portion of the armature, both from above and from beneath, so as to avoid any preponderance of attraction in one direction such as would force the armature strongly against its pivots, and thereby cause friction. By my construction I reduce the upward attraction substantially to that occurring at the varying air-gap between the pole-pieces and the outer portions of the armature, and this upward attraction is so graduated to the weight of the armature that under normal conditions it approximately equals the weight. It results from this that the armature is very sensitively hung, the upward magnetic attraction being approximately balanced by the downward force of gravity, so that the armature is free to respond with great sensitiveness to any relative variations of attraction in the respective magnet-cores due to variations of excitation of their respective coils. The armature may thus with substantial accuracy be denominated a "floating armature," since it rests in substantial equilibrium between the upward attraction of the magnetic force and the downward attraction of gravity.

The composite or differential regulating-magnet may be constructed of two distinct magnets, as shown in Figs. 20, 21, and 22, or it may be constructed with a single magnetic frame, as shown in Figs. 1 to 5 and Fig. 11. As the essential construction is most clearly apparent from Figs. 20 to 22, I will first describe the form there shown. The four-armed plate B here forms no necessary part of the magnetic system, except to support the same, and may be of brass. Its arms a' b' are attached to the respective binding-posts, while its two other arms overlie the respective magnet-frames and are fastened to them to support the composite magnet. This is composed of two U-shaped or horseshoe magnets or magnet-frames M′ and M^2, one of which consists of a core p, wound with a series coil p', and of an L-shaped plate, of which the base m' is fastened to the supporting-plate B, while the downwardly-projecting portion m extends parallel with the core p outside of the coil and at its bottom portion is widened and cut out centrally to form ears n n, which extend down on opposite sides of the armature. The other or shunt magnet frame M^2 consists of a core q, wound with a shunt-coil q', and a similar L-shaped frame, comprising an upper base m' and dependent arm m, divided in like manner at its lower part to form ears $n\ n$. The armature or armature-lever S is shown as composed of two iron armatures, one for each of the magnets, united by a middle portion S′, of non-magnetic material, such as brass, which is formed with a central hole for the passage of the tube C and is pivoted between opposite pivot-screws $o\ o$, engaging it at a point between the legs $m\ m$ of the respective magnets. The iron arms are shown as perforated to receive the lower ends or pole-pieces of the cores $p\ q$, which are tapered or conoidal and enter more or less within the holes, according to the varying positions of the armature. The pivot-screws $o\ o$ may be supported in any suitable way—as, for example, by means of upwardly-projecting ears o' on a collar o^2, preferably of brass, fastened by a set-screw on the central tube C. By this construction the fixed parts or frames of the respective magnets are rendered wholly distinct, while the respective iron armatures, being separated by the brass piece S′, are also kept distinct, so that the two magnetic circuits instituted by the exciting-coils $p'\ q'$ are maintained entirely separate and distinct from one another. The two distinct magnets M′ and M^2 constitute, in effect, one differential magnet, in that the armatures are so mechanically connected as to be forced to move together as a single armature-lever or lever-armature. They might be made integral as a single armature like that shown in Figs. 4 and 5 to similar effect. According to the other construction of magnet (shown in Figs. 4 and 5) the individual magnets M′ and M^2 are to some extent merged together by having one common core or frame. This construction is electrically substantially like that already described, but mechanically is somewhat preferable, as it simplifies the construction of the lamp. Referring to Figs. 4 and 5, the top or base plate B is here integral with the magnetizable frame of the combined magnet, and hence is made of iron. The plate B has four arms, of which $a'\ b'$, as before, are pierced with square holes to receive the binding-posts, while the other two arms m^2 form the yoke for connection between the soft-iron cores $p\ q$ of the magnet and an intermediate third leg or projection m^3, which projects downwardly between the cores $p\ q$. This third leg, which takes the place of the vertical portions $m\ m$ of the magnet-frames in Fig. 2, serves in this construction several purposes. One function is, as before, to form the magnetic connection between the upper ends of the cores $p\ q$ and the armature S. The second function is to form the pivotal support for the armature, for which purpose this leg is made with ears $n'\ n'$, which ears embrace the pivoted portion of the armature freely between them and receive the pivot-screws $o\ o$, Fig. 5, the ends of which enter bushed holes in the armature. A third function of the middle leg m^3 is to constitute the mechanical connection for upholding the central tube C of the lamp, for which purpose the leg is made tubular, Fig. 3, the tube C being fastened within it by set-screws $c\ c$, Fig. 1. The cores $p\ q$, inclosed within the series coil p' and shunt-coil q', respectively, have projecting tapered or conoidal ends entering holes in the respective arms of the armature, which latter is made in one piece of iron. This construction of pole-pieces and armature has the effect of reducing the air-gap and magnetic resistance and in connection with the floating of the armature magnetically, as described, produces a very sensitive differential magnet. The middle leg m^3 is cut away obliquely above the pivotal portion of the armature, as shown in Fig. 4, in order to concentrate the magnetic flux at the sides of the armature and reduce to the minimum any flux entering the armature from above. It may thus be cut away above the armature to greater or less extent in order to give the armature the desired equilibrium. It is important that practically all the magnetic lines of force shall enter the armature at the sides through the ears n' rather than at the top in order to avoid attracting the armature to an extent materially in excess of that which will balance its own weight. In practice and with the proportions shown the adjustment is such that the upward pull, due to magnetism, but slightly exceeds the downward pull, due to the weight of the armature and its dependent parts. Consequently the armature hangs in approximate equilibrium, whereby it responds with great sensitiveness to the differential attraction of the respective magnet-cores $p\ q$.

The circuit connections are preferably made as indicated in the circuit diagram Fig. 11. The main current entering at the positive binding-post a passes through the plate B to the central tube C, (this connection being indicated by the lines 1 2 in Fig. 11,) thence through the tube C to the trolley g, thence through the positive and negative carbons N and O, thence through supporting-arm I, gas-cap G, and connecting-wire 3 to the series coil p', thence by wire 4 to the negative binding-post b. The shunt-current passes through binding-post a by wire 5 to the shunt-coil q', thence by wire 6 to the binding-post b. For adjusting the strength of the series side of the magnet I provide a shunt short-circuiting the series coil p' through an adjustable resistance, this shunt following the wire 7, clamp 8, and more or less of the adjusting resistance-coil 9 and thence through wires 10 to the binding-post b. The relighting-shunt extends from the tube C through the contacts of the relighting cut-out T, (to be described later,) and thence by wire 11, resistance-coil 12, and wire 13 to the binding-post b. A short-circuiting switch S″ is provided, as usual, for making direct connection between the binding-posts, as indicated in Fig. 11, by the wires 1 14, leading to one terminal of the switch, and the wire

15, leading from the other terminal to the binding-post b.

The operation in general is the same as that of previous series arc-lamps governed by a differential magnet. The condition before turning on the current is indicated in Fig. 2. On establishing the current the series coil p' energizes the side of the magnet comprising the core p and attracts the corresponding arm of the armature, which arm being connected by the link l to the clutch R lifts the latter, which tilting engages and lifts the upper carbon, as shown in Fig. 5. The same movement breaks the circuit through the relighting resistance 9. The drawing of the arc introduces a resistance into the main circuit, whereby a proportionate amount of current is diverted through the shunt-coil q', and as the arc burns longer the current thus diverted increases, and the attraction of the core q gradually increases relatively to that of the core p, so that the armature gradually tilts and lowers the clutch R and the carbon until the clutch releases and permits the carbon to feed through it, again tilting and gripping it as soon as the attraction of the series coil p' preponderates over that of the shunt-coil q'. By reason of the sensitiveness of the regulating-magnet the movements of its armature perfectly obey the differential attraction of the magnet. The magnet may be wound with any known combination of series and shunt coils.

The movements of the armature are moderated by a dash-pot U or other retarding device of any usual kind. This is most advantageously connected between the extreme end of the series arm of the armature and the end of the arm of the bracket D beyond where this arm is engaged by the pin f'.

The clutch R, as shown, consists of an arm having a central hole through which the carbon passes, said arm being connected at one end to the link l and having at its other end a slot which is engaged by a guide-pin r, having a flange r' forming the stop for the clutch, and which pin is adjustable up or down in order to vary the height of this stop. The pin is conveniently mounted upon the gas-cap plate F, which has a threaded boss into which the screw-threaded shank of the pin screws, a lock-nut being provided to hold the pin at any adjustment. The clutch-arm is provided with a ring r^2, (shown separately in Fig. 18,) which immediately engages the carbon, this ring being cut away interiorly except at three points s s, which alone engage the carbon, so that the carbon instead of being clamped at two diametrically opposite points, as with an ordinary ring, is clamped at three approximately equidistant points, which results in a free and smooth feeding movement. The ring is fastened to the clutch-arm R by two screws s' s', one of which engages a notch s^2, Fig. 18, in the ring for correctly locating the ring relatively to the arm.

The relighting cut-out T is of novel construction. It comprises a movable conducting-piece, as a cross-bar or roller, so connected to the armature that when the armature is attracted abnormally to the shunt-coil side of the magnet it draws the cross-bar into a converging space between the cut-out terminals, and thereby closes the circuit through the cut-out resistance-shunt. The cross-bar t is preferably formed as a roller, Fig. 9, and hung by a link t', Fig. 10, from the armature on the shunt-coil side of its pivot. The link t' is formed at its lower end with an eye which loosely embraces a groove in the roller t, leaving the latter free to turn. The cut-out terminals are lettered u and u', respectively. Preferably the terminal u is supported on the bracket D by being formed integrally therewith, although it might be otherwise supported. By this construction it is connected through the bracket D to the central tube C and thence to the positive binding-post a. The opposite terminal u' is arranged adjacent to the terminal u, but insulated therefrom, and is connected to the resistance 12 and thence to the negative binding-post b. The terminal u' is shown as of sheet metal, Fig. 8, and fastened against a plate u^2 on the bracket D by means of an insulating-fastening. The arrangement is such that gravity keeps the roller t in approximate contact with the terminal u, and during its upward movement from the position shown in Fig. 3 to that shown in Fig. 2 it enters beneath the yielding arms or fingers of the terminal u' and forms a conducting-bridge between the respective terminals. The respective terminals converge slightly, their faces forming an acute angle, so that the upward movement firmly wedges the roller t in between them. At each movement the roller t turns a little, whereby it continually presents a fresh surface, and its frictional contact with the terminals keeps its surfaces clean. The roller t is kept from any accidental displacement such as might cause it to fail to enter properly between the terminals by means of a pin t^2, closing a guiding-notch t^3, formed in an arm on the bracket D, in which notch the link t' is engaged. To get access to the contacting surfaces it is only necessary to withdraw the pin t^2, whereupon the roller t can be swung outward and the surfaces of the terminals u u' can be examined and cleaned.

The bracket D, which is shown separately in Figs. 6 and 7, has several important functions. By being fastened on the tube C it serves as an abutment against which to clamp the radiator E. Its projecting arm serves as a support for the dash-pot U. The same arm by receiving the pin f' serves to prevent rotary displacement of the radiator. On its opposite side the bracket carries the cut-out terminal u and opposite terminal u' and is formed with the guiding-slot t^3 for the link t'. In addition the bracket is formed with two oppositely-projecting arms v v', Fig. 7, which arms, as shown in Fig. 1, serve as the supports, respectively, for the lower ends of the relighting resistance-coil 12 and the adjusting resistance-coil 9, the upper ends of these coils being mechanically connected to the respective binding-posts, although the coil 9 is insulated from the binding-post a.

The radiator E will now be described. In lamps of the character shown, wherein to secure compactness the arc (usually an inclosed arc) is arranged as close as possible beneath the mechanism-case, much difficulty has been experienced by reason of the upward transmission of heat from the arc to the mechanism within this case. The object of this feature of my invention is to remedy this difficulty by effecting a radiation of heat between the arc and the interior of the mechanism-case. Such radiation is the function of the radiator E. This radiator comprises two approximately horizontal plates w and w', which may or may not be connected in one casting through an intervening neck or hub w^2, Fig. 13. The plates w w' are somewhat widely separated to form between them an air-space or radiating-chamber V. The plate w serves to close the bottom of the mechanism-case, while the plate w' serves as a top plate or roof for the chamber inclosed within the outer globe Q. (See Fig. 2.) The highly-heated air or gases in this chamber rising to the top thereof communicate their heat to the plate w', which in turn radiates it into the air-chamber V between the plates. This air-chamber V is open to the outer air on all sides beneath the lower end of the casing P, so that air may freely circulate through this chamber from all sides. In case the wind is blowing the circulation will naturally be in a direction approximately diametrically across the chamber. In still air a draft will be occasioned by the heat in the manner indicated approximately by the arrows in Fig. 13. If the plates w w' alone were used, the surface of the latter plate would be insufficient for the effective radiation of heat to the air, and hence I increase this surface by forming the plate w' with flanges or ribs projecting perpendicularly from it into the air-chamber V. These flanges or ribs are lettered w^3 w^4 and are shown as projecting radially in vertical planes, so as to leave between them radial channels for circulation of air. As shown, the alternate plates w^3 are straight on their upper edges, Fig. 3, and of less projection than the intervening plates w^4, which latter are cut away toward the middle, as shown in Fig. 13, to avoid choking the air-channels. This special construction and arrangement of the plates or flanges, however, is not essential, as any arrangement of upwardly-projecting plates, flanges, or other projections adapted to increase the radiating-surface, and thereby augment the rate of conduction of heat from the radiator to the air, will be within my invention. The upper plate w, if made integral with the lower plate, is preferably connected to it only through the hub w^2 in order to avoid as far as possible direct conduction of heat into the mechanism-case. The radiator is shown as provided with an opening 16, Fig. 3, for the passage of the link l (the bracket D also having a similar opening) and with also an opening 16' for the passage of the conducting-wire 3, Fig. 1. The lower plate w' of the radiator slopes from the center outward in order to shed any rain that may drive in, and at its outer edge is extended downward to form the flange or rim i, before described, so that this rim serves to shed rain onto the exterior of the globe-holder Q', which in turn sheds it over the outer globe.

When the globe-holder Q' is disconnected from the lamp-body and the globe lowered, so as to hang by the chain, as shown in Fig. 15, it is often desirable to be able to readily disconnect the chain, so as to wholly sever the globe-holder from the lamp-body. To this end I provide the upper end of the chain k with an eye k', (shown in elevation at the right of Fig. 1,) and I provide a suitable pin or stud k^2 upon some convenient part of the lamp-body, over which pin or stud the eye k' may be dropped, so that it will hang in place normally by its weight, but so that when it is desired to disconnect it it is only necessary to lift it sufficiently to free it from the pin or stud. I preferably form the pin or stud k^2 as an integral part of the radiator E, as shown in Fig. 1 and in plan in Fig. 12. Beneath the pin k^2 the flange i is provided with a slight recess or vertical groove i', Fig. 12, in which the eye k' may lie.

To prevent accidental disengagement of the outer-globe holder Q', I provide a catch or latch engaging its neck and adapted either to prevent its turning or to prevent its lifting. By preventing either of these movements the disengagement of its bayonet-notches from the pins j', projecting within the pendent flange i, is prevented. The catch is preferably a gravity-catch, and for convenience of manipulation it is preferable to have some connection with the catch that is easily found and grasped in order that by moving this connection the catch may be withdrawn. These several requisites I preferably and most simply supply by providing the eye k' with a lateral projection k^3, Fig. 1, adapted to project through a hole i^2 in the pendent flange i (best shown in Fig. 14) and into a corresponding hole or notch i^3, Fig. 15, in the neck of the globe-holder Q', as clearly shown in Fig. 1. As the eye k' hangs from its upper end, its weight causes it to keep the projection k^3 in place until the operator to disengage the catch pulls upon the chain k. Thus the eye serves the double purpose of a suspension for the chain and a catch for locking the globe-holder, while the chain serves as a handle for this catch. By making the hole i^3 sufficiently small the projection k^3, entering it, serves to prevent both the lifting and the turning of the globe-holder; but any engagement that will prevent either of these movements will suffice.

The inner-globe holder K is necessarily a yielding or spring holder for pressing the globe upwardly into firm contact with the gas-cap G. I construct it, as shown in Fig. 19, with an upright plunger or rod y, having free vertical play in a socket-piece L', carried at the bottom of the bail L, formed at its upper end with three (more or less) arms or fingers y' for engaging the globe and formed at its lower end with a head y^2. It is pressed upwardly by a spiral spring y^3, which reacts against and seats within the socket-piece L'. To release the globe, it is only necessary to pull down the rod y and then swing the bail L to one side. This construction of globe-holder is not herein claimed, being made the subject of a separate application filed March 9, 1903, Serial No. 146,944.

The construction of the gas-cap for the inner globe presents some novel features. Instead of being of one plate only it is built up of two parts F and G. The part G, which alone touches the inner globe, is a ring separated from the mechanism-case or radiator E by two insulations. It is supported upon but insulated from the cross bar or plate F, while this plate is supported by but insulated from the bottom plate of the radiator E. The construction of the upright arms f, integral with the radiator, is advantageous in bringing the insulated connection down to where it is readily accessible and avoids forming holes through the radiator or into the mechanism-case for making this connection. The plate F, which is shown separately in plan in Fig. 23 and in elevation in Fig. 24, is formed with a central neck 17 and with two upwardly-projecting necks 18 19 on opposite sides thereof. The central neck 17 is that through which the upper carbon N passes. The necks 18 19 serve for the attachment of the gas-ring G, and one of them serves also for making electrical connection with the lower or negative carbon holder. As shown, screws 20 and 21 pass through insulating-bushings in the necks 18 19 and engage the gas-ring G. One of these, 20, has at its upper end a coupling for uniting to it the conducting wire or rod 3, which passes up through the radiator into the mechanism-case. Upon unscrewing this coupling the electric connection may be severed for disconnecting the gas-ring. The gas-ring G serves as a conducting connection between the wire 3 and the arm I, supporting the carbon-holder J, the upper end of this arm I being fastened in a socket in the gas-ring. By extending the necks 18 19 upwardly the insulated screw connection is lifted to where there is no possibility of the insulation being bridged by accumulations of carbon-dust. In this preferred construction the gas-cap is, in fact, composed of the central part of the plate F, together with the annular part G. The latter (shown in plan in Fig. 25) is rabbeted to receive the upper end of the globe H. It is insulated from the plate F by the insulation 22, which latter is perforated centrally to enable the central neck 17 on the plate F to project downwardly within the annular part G of the gas-cap.

The neck 17 of the gas-cap is of novel construction, applicable whether the gas-cap as a whole is made of two parts F G or of one part. It is desirable that the opening through which the carbon passes shall be as small as possible in order to prevent access of air. The gas-cap is commonly made of iron to withstand the heat, and much difficulty has been experienced by reason of the cap rusting and causing the carbon to stick. This I overcome by forming the neck 17 of the gas-cap of a diameter considerably larger than that of the carbon, so as to leave a free space between, as best shown in Fig. 3, and providing the neck with one or more bushings of a suitable refractory and non-oxidizable metal, making as close a fit with the carbons as is practicable. I prefer two bushings z z', located as shown in Fig. 3, at the top and bottom of the neck, so as to leave a confined space between them. I prefer to form these bushings of copper, as this is the most refractory and least oxidizable metal available at a cost which is not prohibitory. By these means the difficulties heretofore encountered are obviated.

The carbon carrier or trolley g, which slides freely in the tube C, has a carbon-holder g' at its lower end for engaging the carbon N and has at its upper part contact-springs pressing lightly outward to make electrical connection with the tube C, these springs being of the construction shown in my said Patent No. 678,607. The carbon-holder g', however, is of novel construction. It is formed, as shown in Fig. 26, of two jaws 23 23, of elastic sheet metal, each pressed or struck up in a die to the form shown in Figs. 26 and 27, the lower part of the two springs being expanded to a diameter slightly smaller than that of the carbon, so as to cling upon the latter when it is thrust up within them, while the upper part or neck of the spring-jaws is contracted to a smaller diameter to fit the contracted neck portion of the trolley, to which the jaws are fastened by screws 24 24 or other suitable means. From the neck of the trolley a central projection 25 is carried downward to serve as a stop to prevent the carbon being pushed too far up within the clamp. This form of clamp or carbon-holder grips the carbon firmly but yieldingly and makes a very perfect electrical contact therewith. The spring-jaws 23 are formed with indentations 23^a, whereby the socket of the clamp or holder is locally contracted, so as to form a sort of rocking engagement with the carbon. These indentations are preferably formed as ribs or beads which extend circumferentially around the socket or holder; but they might be otherwise formed. By this conformation of the holder the carbon is embraced or gripped locally at points about an approximately circumferential line. The purpose of this construction is to so engage the carbon as to permit of its being adjusted universally or in any direction in order to compensate for any crookedness of the carbon, and thereby enable the carbon as a whole to be correctly alined with the carrier or, in other words, with the tube C, so that the lower part of the carbon can pass freely through the gas-cap. Thus with a carbon which is slightly crooked its tendency to bind in the gas-cap is entirely obviated.

I provide an insulating-suspender for the lamp, as shown in Figs. 1 and 2. The hood A has, as usual, perforated ears 26, between which an insulating spool or button 27 is supported on a cotter-pin 27′. This insulator 27 is embraced by a U-shaped link 28, Fig. 1, between the upper legs of which another insulator, 29, is confined on a cotter-pin 30, passing through perforations in the upper ends of the legs. Around this insulator 29 passes the suspension loop or link 31. The links 28 and 31 have, respectively, ears 32 and 33, shaped to cause any drip to fall outwardly instead of falling centrally beneath. Thus the lamp is suspended through a doubly-insulating suspension device.

It must not be inferred from the minuteness with which I have described the several details of construction of the preferred embodiment of my lamp which is shown in the drawings that my invention is by any means limited to these details. My invention is susceptible of various modifications in matters of mechanical construction and in the substitution of mechanical and electrical equivalents. For example, the series and shunt coils may be otherwise wound on the differential magnet according to any known or suitable method.

What I claim is—

1. A differential magnet and armature, the latter pivoted to rock as the relative strength of the magnet-poles varies, the magnet-poles and armature relatively shaped to distribute the magnetic flux symmetrically so that the armature is attracted in line with the poles and without imparting end thrust thereto, and the armature acted on by a force opposing and substantially equal to the normal attraction of the magnet, so that under normal excitation the armature floats in substantial equilibrium, whereby pressure against its pivotal surfaces is mainly avoided and a high degree of sensitiveness is attained.

2. A differential magnet and armature, the latter pivoted to rock as the relative strength of the magnet-poles varies, the magnet-poles and armature relatively shaped to distribute the magnetic flux symmetrically so that the armature is attracted in line with the poles and without imparting end thrust thereto, the magnet arranged with its poles projecting downward and the armature arranged beneath it so that the downward force of gravity shall oppose and substantially equalize the normal attraction of the magnet, so that under normal excitation the armature floats in substantial equilibrium, whereby pressure against its pivotal surfaces is mainly avoided, and a high degree of sensitiveness is attained.

3. In an arc-lamp, a differential magnet with downwardly-projecting legs, and an armature pivoted between their poles with its ends adjacent to their respective pole-pieces, the pole-pieces and armature being relatively conformed to react symmetrically, whereby the magnetic attraction is substantially in line with the poles, and the armature of such weight as to hang in substantial equilibrium between the normal upward attraction of said magnet and the downward force of gravity.

4. In an arc-lamp, a differential magnet comprising two cores, a series coil magnetizing the one, a shunt-coil magnetizing the other, a lever-armature pivoted between the pole-pieces of said cores with its opposite arms arranged beneath and adjacent to the respective pole-pieces and conformed thereto to react symmetrically therewith, and a magnetic connection between the middle portion of the armature and each of said cores, whereby two magnetic circuits are formed through the respective coils and through the respective arms of the armature, said armature being of such weight as to hang in substantial equilibrium between the normal upward attraction of said magnet and the downward force of gravity.

5. In an arc-lamp, a differential magnet comprising a magnet-frame having three downwardly-projecting legs, the outer ones wound respectively with shunt and series coils, and an armature pivoted to the intermediate leg, with its ends adjacent to the poles of said outer legs, the pole-pieces and armature being relatively conformed to react symmetrically, the armature being of such weight as to hang in substantial equilibrium between the normal upward attraction of said magnet and the downward force of gravity.

6. In an arc-lamp, a differential magnet comprising a magnet-frame having three downwardly-projecting legs, shunt and series coils magnetizing the two outer legs, the middle leg being central and substantially tubular, and the upper-carbon holder movable within said central leg.

7. In an arc-lamp a magnet-core having three legs, an armature pivoted at its middle part to the middle leg, with its ends adjacent to the outer legs, said middle leg extending beyond and parallel with the pivotal portion of said armature to distribute the magnetic flux thereto, a shunt-coil magnetizing one outer leg, and a series coil magnetizing the other outer leg.

8. In an arc-lamp a magnet-core having three legs, an armature pivoted at its middle

part to the middle leg, with its ends adjacent to the outer legs, said middle leg having pivotal ears embracing and extended parallel with the pivotal portion of said armature to distribute the magnetic flux thereto, a shunt-coil magnetizing one outer leg, and a series coil magnetizing the other outer leg.

9. In an arc-lamp, a magnet-core having three legs, the outer legs wound with shunt and series coils respectively, and the middle leg projecting between them, and an armature pivoted to the middle leg, the latter reduced above and adjacent to the armature to diminish the upward attraction for the armature at its pivotal portion.

10. In an arc-lamp, a magnet-core having three downwardly-projecting legs, the outer legs wound with shunt and series coils respectively, and their ends projecting beyond the coils as conoidal pole-pieces, and an armature beneath said coils, pivoted to the middle leg and having holes in its end portions coinciding with and receiving said pole-pieces, and the armature of such weight as to hang in substantial equilibrium between the normal upward attraction of said magnet and the downward force of gravity.

11. In an arc-lamp, the combination of a top hood, a magnet-core having an upper base-plate attached beneath said hood, and a pendent central tube rigidly connected to and suspended from said base-plate and projecting downward.

12. In an arc-lamp, the combination of a suspension-hood, a magnet-core having an upper base-plate adapted for attachment to said hood, and downwardly-projecting legs, one of which is central, and the lower parts of the lamp attached to said central leg, whereby the magnet-core serves as the medium for mechanically uniting the upper and lower members of the lamp.

13. In an arc-lamp, a mechanism-case and its suspension-hood, a magnet-core having an upper base-plate attached to said hood, and a pendent tubular leg central to said case, combined with a central tube fixed within said leg and to which the lower members of the lamp are attached.

14. In an arc-lamp, the combination of a mechanism-case, its top hood, a magnet-core formed with an upper base-plate attached beneath said hood, and with a pendent tubular central leg, a central tube fixed within said leg, and projecting downward, and the bottom plate of the mechanism-case attached to said tube.

15. In an arc-lamp, the combination of a mechanism-case, its top hood, a magnet-core having an upper base-plate attached beneath said hood, with a central tube C passing through and fixed to said base-plate and projecting downward, a bracket D fixed on said tube, and the bottom plate of the mechanism-case attached to said tube beneath said bracket.

16. In an arc-lamp, the combination of a top hood, a magnet-core having an upper base-plate attached beneath said hood, with a central tube C passing through and fixed to said base-plate and projecting downward, a bracket D fixed on said tube, and the bottom plate of the mechanism-case attached to said tube and having a non-rotative connection with said bracket.

17. In an arc-lamp, the combination of a top hood, a magnet-core formed with an upper base-plate attached beneath said hood, a central tube C fixed to said plate and projecting downward, a bracket D fixed on said tube and having a laterally-projecting arm, the magnet-armature, and a dash-pot connected between said armature and said bracket-arm.

18. In an arc-lamp, a heat-radiator between the arc and the mechanism-case comprising a plate having heat-radiating projections.

19. In an arc-lamp, a radiator comprising two horizontal plates separating the mechanism-case from the globe inclosing the arc, with an intervening ventilating-space, and heat-radiating projections from the lower plate for promoting radiation.

20. In an arc-lamp, a radiator comprising two horizontal plates separating the mechanism-case from the globe inclosing the arc, with an intervening ventilating-space, and radial plates projecting into said space from the lower plate for promoting radiation.

21. In an arc-lamp, a heat-radiator between the arc and the mechanism-case, comprising two horizontal plates separated to form an intervening ventilating-space, and connected together by a central tube, the lower plate having heat-radiating projections entering said space.

22. In an arc-lamp, the combination with a central tube C, of a heat-radiator comprising two horizontal plates formed in one integral casting with a central hub, said hub fitting over and attached to said tube, and said plates spaced apart to form an intervening ventilating-space, the lower plate having radiating projections entering said space.

23. In an arc-lamp, the combination of a suspension-hood, a cylindrical casing entering at its upper end within the lower part of said hood, and a heat-radiator supported from said hood and comprising two horizontal plates separated to form a ventilating-space, the upper plate arranged adjacent to the lower edge of said casing and adapted to form the bottom plate of the mechanism-case, and the lower plate arranged beneath the lower edge of said casing, whereby to expose said ventilating-space to communication with the outer air, said lower plate sloping from the middle outwardly, and turned down at its outer periphery to form a pendent flange, combined with the outer-globe holder having a contracted neck fitting up within said flange.

24. In an arc-lamp, the combination of a suspension-hood, a cylindrical casing entering at its upper end within the lower part of

said hood, and a heat-radiator supported from said hood and comprising two horizontal plates separated to form a ventilating-space, the upper plate arranged adjacent to the lower edge of said casing and adapted to form the bottom plate of the mechanism-case, and the lower plate arranged beneath the lower edge of said casing, whereby to expose said ventilating-space to communication with the outer air, and both plates of smaller diameter than said casing, whereby to admit of the removal of the casing downwardly.

25. In an arc-lamp, the combination of a suspension-hood, a plate w' supported beneath said hood and having a pendent peripheral flange i, a cylindrical casing the upper end of which enters within the lower portion of the hood, said plate and flange of smaller diameter than the interior of said casing to permit downward removal of said casing, and a globe-holder having a contracted neck fitting up within said flange.

26. In an arc-lamp, a heat-radiator E formed with pendent integral arms $f f$, combined with a gas-cap attached to and insulated from said arms, and with means for holding the inner globe against said gas-cap.

27. In an arc-lamp, the combination of a suspension-hood, a central tube with its upper part connected to said hood, a plate w' fastened on the lower part of said tube, said plate having pendent arms $f f$, the gas-cap for the inner globe supported from said arms, and means for holding the inner globe up against said gas-cap.

28. In an arc-lamp, a cast plate forming the bottom of the mechanism-case having integral arms projecting beneath it, a swinging bail hung from said arms, and a clamp carried by said bail for holding the inner globe in place.

29. In an arc-lamp, the combination of a plate w' having pendent arms $f f$, a cross-head F attached to said arms, a gas-ring G fastened to and insulated from said cross-head, the lower-carbon holder J and its supporting-arm I fastened to said ring G.

30. In an arc-lamp, the combination of a cross-head F, means for supporting it beneath the lamp-body, a gas-ring G fastened beneath and insulated from said cross-head, the cross-head formed with upwardly-extending necks 18, 19, and screws passing through insulating-bushings in said necks for fastening said ring.

31. In an arc-lamp, the combination of a cross-head F, means for supporting it beneath the lamp-body, a gas-ring G fastened beneath and insulated from said cross-head, a fastening-screw for said ring passing through a bushed neck on said cross-head, a circuit-wire extending from the mechanism-case down to said cross-head and joined by a detachable coupling to said fastening-screw, the lower-carbon holder J and its supporting and conducting arm I fastened to said ring G.

32. In an arc-lamp, a plate w' insulated from the lamp-circuit and having pendent arms $f f$, a gas-cap supported from said arms, a swinging bail L hung from said arms, and a spring-clamp carried by said bail for pressing the inner globe up against said gas-cap, whereby the insulation of said plate insulates said bail.

33. In an arc-lamp, a gas-cap for closing the top of the inner globe, having a neck through which the carbon feeds with its opening considerably larger than the carbon, and two bushings of refractory non-oxidizable metal in said neck making a close fit with the carbon and with a confined space between said bushings.

34. In an arc-lamp, a gas-cap comprising an upper plate F having a central neck through which the upper carbon may pass, a ring G fastened beneath said plate with intervening insulation, and the lower-carbon holder connected to said ring.

35. In an arc-lamp, a gas-cap comprising upper and lower plates fastened together with intervening insulation, the lower plate adapted to receive the upper margin of the arc-inclosing globe, the lower-carbon holder hung by a conducting-arm from said lower plate, and said upper plate having a central neck through which neck the upper carbon may pass.

36. In an arc-lamp, a feed-clutch for the carbon comprising an arm having a central hole, and a ring fastened to said arm and having its inner peripheral portion cut away intermittently, leaving arc-shaped concave faces which engage the carbon.

37. In an arc-lamp, a feed-clutch for the carbon comprising an arm having a central hole, and a ring fastened to said arm, said ring formed on one side with a notch, and one of the fastening-screws arranged to enter said notch to correctly locate the ring relatively to the arm.

38. In an arc-lamp, a clutch-ring for the carbon-feed having its inner peripheral portion cut away intermittently leaving internal projections s s with arc-shaped concave faces which alone engage the carbon.

39. In an arc-lamp, a cut-out comprising opposite circuit-terminals having converging surfaces, and a movable conducting-piece rotatively connected to the armature and adapted by an abnormal movement thereof beyond the feeding movement to be moved against said terminals to form a bridge between them, the faces of said terminals contacting with said piece being at an acute angle with one another, so that said movement wedges said piece between their faces and in so doing rotates it, to continually change the contacting surfaces.

40. In an arc-lamp, a cut-out comprising opposite circuit-terminals having converging surfaces, the one substantially rigid and the other elastic, and a movable conducting-piece loosely connected to the armature and adapted by an abnormal movement thereof beyond the feeding movement to be moved against

said terminals to form a bridge between them, the faces of said terminals contacting with said piece being at an acute angle with one another, so that said movement wedges said piece between their faces.

41. In an arc-lamp, a cut-out comprising opposite circuit-terminals having converging surfaces, and a movable conducting-piece loosely connected to the armature and adapted by an abnormal movement thereof beyond the feeding movement to be moved against said terminals to form a bridge between them, the faces of said terminals contacting with said piece being at an acute angle with one another, and at varying angles relatively to the direction of movement of said conducting-piece, so that said movement wedges said piece between their faces and in so doing tends to rotate it.

42. In an arc-lamp, a cut-out comprising opposite circuit-terminals, a roller, and a rod rotatively engaging said roller and pivotally connected to the armature, whereby the roller is moved by the armature against and between said terminals and may yield laterally in entering between them.

43. In an arc-lamp, a cut-out comprising opposite circuit-terminals, a movable piece adapted to enter between said terminals, and a rod connecting said piece with the armature and adapted to swing outward independently of movement of the armature to expose the contacting surfaces of said terminals.

44. In an arc-lamp, a cut-out comprising opposite circuit-terminals, a movable piece adapted to enter between said terminals, a rod connecting said piece with the armature, and a stationary guide for said rod adapted normally to guide said piece against said terminals and adapted to be opened to disengage said rod and permit the piece to be swung out to expose the terminals.

45. In an arc-lamp, a central tube C and a bracket D fixed thereon, and a cut-out, said bracket supporting a circuit-terminal of said cut-out, a second terminal mounted adjacent thereto, and a loose piece connected to the armature and movable against said terminals.

46. In an arc-lamp, a central tube C, a bracket D, a relighting cut-out having its terminals supported by said bracket, and a resistance-coil in circuit with said cut-out, said bracket formed with a projecting arm to which one end of said coil is attached.

47. In an arc-lamp, the combination of a suspension-hood, binding-posts passing through said hood, a central tube supported from said hood, a bracket D fixed on said tube and having laterally-projecting arms terminating beneath said binding-posts, and resistance-coils mechanically connected at their upper ends to said binding-posts and at their lower ends to said arms.

48. In an arc-lamp, a carbon-carrier and carbon-holder, the latter comprising concave sheet-metal springs reduced at their upper parts to smaller diameter than at their lower portions, their upper parts attached to a reduced neck on said carrier, and their lower portions projecting below said carrier and forming a tubular socket adapted to yieldingly receive and embrace the carbon.

49. In an arc-lamp, a carbon-carrier having a reduced neck at its lower part, and a carbon-holder consisting of concave sheet-metal springs, their lower portions adapted to fit and yieldingly embrace the carbon, and their upper portions of smaller diameter fitting and fastened to said neck.

50. In an arc-lamp, a carbon-carrier and carbon-holder, the latter formed of concave springs with their lower portions projecting below the carrier and adapted to form a yielding socket for embracing the carbon, their upper portions fastened to said carrier, and said carrier formed with a downward projection within said holder adapted to limit the thrust of the carbon thereinto.

51. In an arc-lamp, a carbon carrier and holder, the latter comprising concave sheet-metal springs projecting below the carrier so that their projecting portion constitutes a tubular yielding socket for the carbon, and said springs formed with indentations contracting said socket to locally embrace the carbon and permit of universal adjustment of the latter to bring it into alinement with the carrier.

52. In an arc-lamp, a globe-holder Q′ adapted to carry a globe beneath it, connected to the lamp-body by a suspension-chain k, the lamp-body above the globe formed with a bottom plate E having on its top an integral pin or stud k^2 engaged by the terminal eye k' of said chain, whereby the globe-holder may be readily disconnected from the lamp-body.

53. In an arc-lamp, a globe-holder Q′ connected to the lamp-body by a suspension-chain k, the lamp-body formed with a casing P and bottom plate E, the latter extended below said casing and having a stud k^2 projecting up within said casing and adapted to engage the terminal eye k' of said chain.

54. In an arc-lamp, a lamp-body having a pendent flange at its bottom, combined with a globe-holder having a neck entering up within said flange, said flange and neck having interengaging fastening provisions adapted to engage or disengage by a movement of the neck within the flange, and an independent catch adapted to lock said neck and flange together to prevent the disengaging movement of the neck, whereby to disengage the globe-holder such catch must first be withdrawn.

55. In an arc-lamp, a lamp-body having a pendent flange at its bottom, combined with a globe-holder having a neck entering up within said flange, said flange and neck having interengaging fastening provisions adapted to engage or disengage by a movement of

the neck within the flange, and an independent catch adapted to lock said neck and flange together to prevent the disengaging movement of the neck, consisting of a projection adapted to enter through coinciding holes in said flange and neck.

56. In an arc-lamp, a lamp-body having a pendent flange at its bottom, combined with a globe-holder having a neck entering up within said flange, said flange and neck having interengaging fastening provisions adapted to engage or disengage by a movement of the neck within the flange, and an independent catch adapted to lock said neck and flange together to prevent the disengaging movement of the neck, said catch consisting of a gravitating part hung from above and having a projection tending to enter coinciding holes in said flange and neck, whereby said gravity-catch must be lifted to withdraw said projection before the globe-holder can be disengaged.

57. In an arc-lamp, a globe-holder having means for normally connecting it to the lamp-body and also connected therewith by a suspension-chain k having a terminal eye k', said eye having a projection adapted to engage the globe-holder when the latter is in place to lock it against the disengaging movement, and adapted upon pulling said chain to be displaced to withdraw said projection and unlock said globe-holder.

In witness whereof I have hereunto signed my name in the presence of two subscribing witnesses.

JAMES J. WOOD.

Witnesses:
FRED S. HUNTING,
W. L. BLISS.