J. T. H. DEMPSTER.

ARC LAMP.

APPLICATION FILED FEB. 29, 1904. RENEWED APR. 7, 1906.

905,800. **Patented Dec. 1, 1908.**

2 SHEETS—SHEET 1.

Fig. 1.

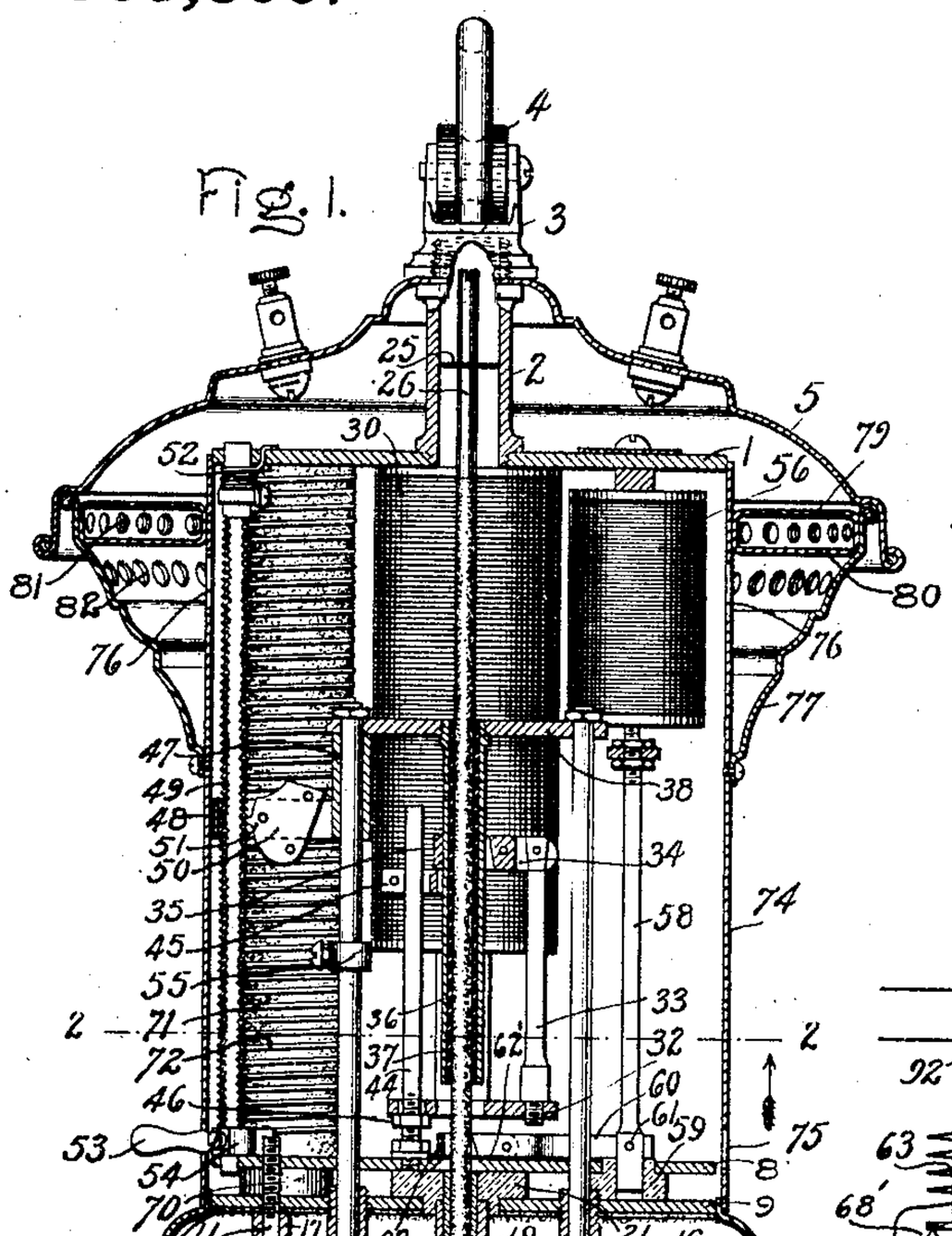


Fig. 2.

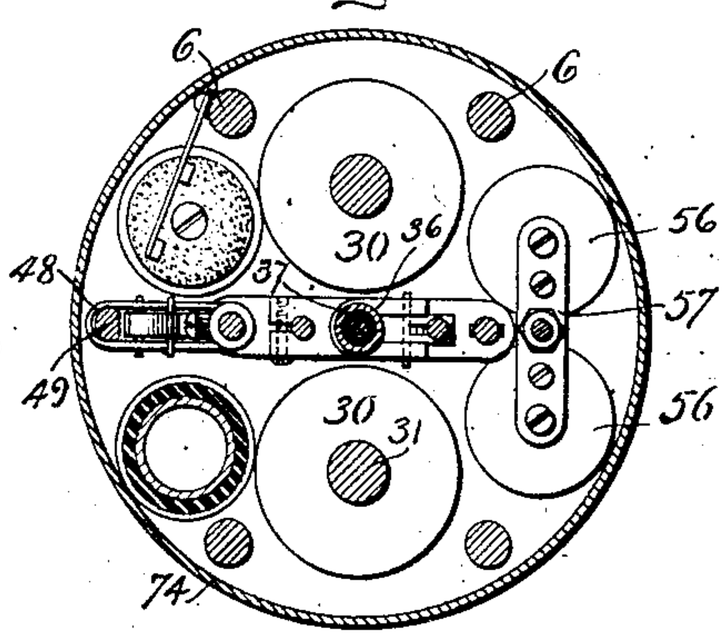
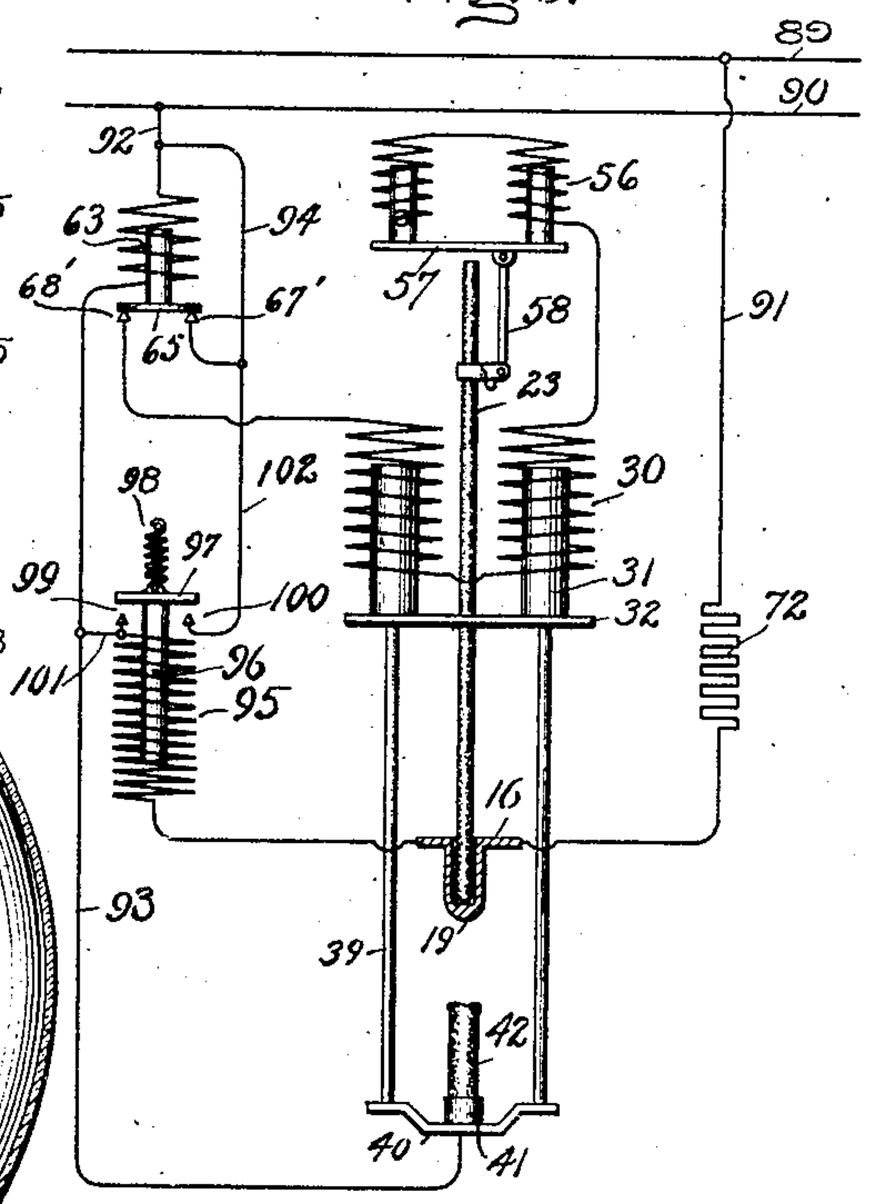


Fig. 3.



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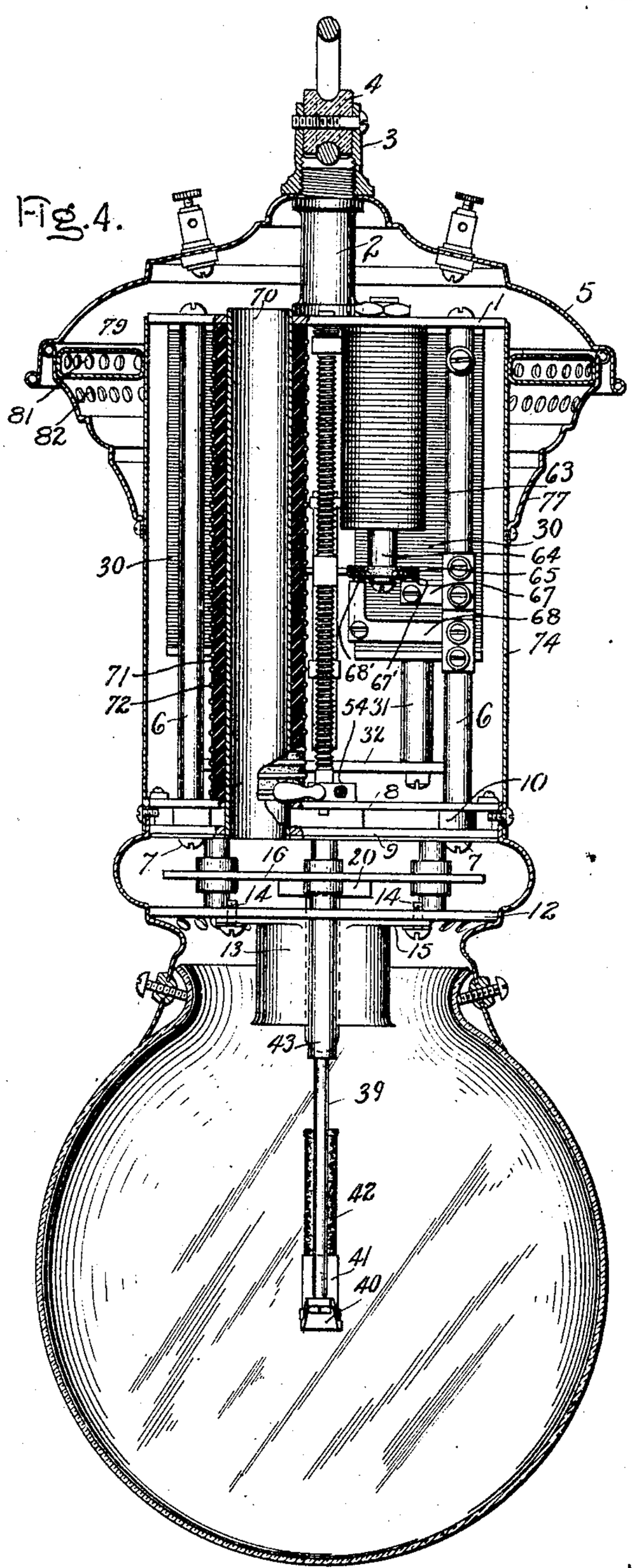
2 SHEETS—SHEET 2.

Fig. 4.



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UNITED STATES PATENT OFFICE.

JOHN T. H. DEMPSTER, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

ARC-LAMP.

No. 905,800. Specification of Letters Patent. Patented Dec. 1, 1908.

Application filed February 29, 1904, Serial No. 195,781. Renewed April 7, 1906. Serial No. 310,473.

To all whom it may concern:

Be it known that I, JOHN T. H. DEMPSTER, a citizen of the United States, residing at Schenectady, in the county of Schenectady, State of New York, have invented certain new and useful Improvements in Arc-Lamps, of which the following is a specification.

With some materials which may be employed in the composition of the electrodes of arc lamps, it has been found that the electrodes, or at least their tips, are poor conductors of electricity when cold, though when heated the same electrodes may be good conductors throughout their length. This property may be characteristic of the material of which the electrode is originally made, or it may be a property possessed by the material formed by the action of the arc at the electrode tip. In order to facilitate the starting of an arc from such an electrode, I have devised means for heating the electrode at starting to increase its conductivity.

Where the material of which the negative electrode in direct-current lamps is made is suitably chosen, a flaming or luminous arc yielding an intense light is obtained. In such cases the positive electrode may be so constructed that it is practically unconsumed in the operation of the lamp.

The means for heating the electrode tip which I have devised is shown in the drawings accompanying this specification as embodied in an arc lamp in which the positive electrode of the lamp is not consumed by the arc. Some of the features of my invention are peculiarly adapted for use in such an embodiment. My invention in other aspects however is not limited to any particular form of embodiment.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of my invention however, reference may be had to the accompanying drawings and description in which I have illustrated and described somewhat in detail one embodiment of my invention.

Of the drawings, Figure 1 is an elevation, partly in section, of an arc lamp equipped with my invention; Fig. 2 is a sectional plan taken on the line 2—2 of Fig. 1; Fig. 3 is a diagram illustrating the circuit arrangements of the lamp; and Fig. 4 is an elevation with parts in section, taken at right angles to the view shown in Fig. 1.

Referring to the drawings, a disk 1 is shown as representing the top member of the lamp mechanism proper. A tubular member 2 screwed into a threaded aperture centrally located in the disk 1 is screw-connected at its upper end to the bracket 3 in which the lamp-supporting pulley insulator 4 is supported. A hood 5 forming the top of the lamp casing is secured between the bracket 3 and the tubular member 2.

Posts 6 extend downwardly from the under side of the member 1 to which they are screw-connected. These posts have secured to them at their lower ends by means of screws 7 a pair of disk platforms 8 and 9 which are parallel to each other and to the disk 1. Spacing members 10 are employed to separate the platforms 8 and 9. Bolts 11 screwed into threaded apertures formed for the purpose in the platforms 8 and 9 carry at their lower end a third platform 12 which is also parallel to the disk 1. A large aperture is centrally formed in the platform 12. A cylindrical member 13 is secured to the under side of the member 12 by screws 14 passing through extensions 15 from the member 13.

A disk-shaped member 16 formed of some material which is a good conductor both of heat and electricity, such as wrought copper, is held parallel to and about midway between the platforms 9 and 12 by means of suitable space members or collars 17 and 18. The collars 18 at least are formed of insulating material and serve to insulate the disk member 16 from the bolts 11.

A tubular member 19, preferably formed of wrought copper, is secured in a threaded aperture formed centrally in the member 16, the member 19 being formed with a collar or flange 20 which abuts against the under side of the member 16. The disk 16 and member 19 form the main positive electrode of the lamp. The disk 16 as formed and located has a large heat-dissipating capacity and carries heat away from the member 19 fast enough to prevent its destruction by the arc which extends from its lower end in the operation of the lamp. The lower portion of the member 19 passes axially through the cylindrical member 13, the extreme lower end of the member 19 projecting somewhat below the lower end of the cylindrical mem-

ber 13. The upper end of the member 19 extends through an aperture formed for the purpose in the platform 9 terminating at about the level of the upper surface of that platform. A collar 21 formed of suitable insulating material such as porcelain or the like separates the tubular member 19 from the platform 9. The lower end of the member 19 is closed as shown in Fig. 1, the end wall of the member being considerably thicker than the side wall. A projection 22 extends axially a short distance upward from the end wall of the member.

A pencil 23 of carbon or the like, somewhat smaller in diameter than the bore of the tubular member 19, extends into the tubular member 19. Normally its lower end rests on the upper end of the projection 22. As will be hereinafter explained, under some circumstances an arc is drawn between the projection 22 and the pencil 23 which forms an auxiliary electrode. As shown in Fig. 1 a cylindrical jacket 24 of suitable fire-proof insulating material, such as mica, lines the upper portion of the tube 19 and insulates that portion of the member from the pencil 23. A washer 25 of insulating material is clamped against the upper end of the pencil 23 by a bolt 26 which is screwed axially into the end of the pencil. The washer 25, which has a sliding fit in the tubular member 2, positions the upper end of the pencil 23 centrally with respect to the member 2.

A pair of tubular magnet coils 30 have their upper ends secured to the under side of the member 1. The cores 31 of these coils are connected at their lower end by a yoke member 32. A post 33 which is carried by and extends upwardly from the yoke 32 has pivotally secured to its upper end the pawl member 34 of a clutch, the yoke 35 of which surrounds a tubular member or sleeve 36 which in turn surrounds the carbon pencil 23, being separated therefrom by an insulating layer or bushing 37. The upper end of the tubular member 36 is secured to a cross-head 38. Bolts or rods 39 secured at opposite ends of the cross-head pass downwardly through apertures formed for the purpose in the disks 8, 9, 16 and 12 and are secured at their lower ends to the ends of a yoke member 40. The yoke member 40 carries on its upper side and midway between its ends a socket 41 in which the lower electrode 42 of the lamp is held in alinement with and below the tubular member 19.

Sleeves 43, threaded into the platform 9, extend through the disks 16 and 12 to a point somewhat below the lower end of the cylindrical member 13 and serve as guiding members in which the rods 39 have a sliding movement. As is clearly shown in Fig. 1, the apertures in the disk 16 through which the sleeves 43 pass are so formed that the disk 16 does not engage the sleeve 43 but is separated therefrom by an insulating air space. A post 44, the lower end of which is screwed into a threaded aperture formed in the platform 8, extends upwardly therefrom parallel to the pencil 23 and tubular member 36. A member 45 adjustably secured to the post 44 near its upper end forms a stop against the upper surface of which the under surface of the ring 35 rests when the coils 30 are deënergized and the cores 31 assume their lowest position. An adjustable nut 46 on the post 44 near its lower end forms a stop against which the under side of the cross-head 23 rests in that condition of the apparatus. The post 44 which passes through an aperture formed for the purpose in the cross-head 32 forms a guide for positioning the cross-head.

The left-hand rod 39 as viewed in Fig. 1 is surrounded near its upper end by the sleeve portion 47 of a member 48. The outer end of the member 48 embraces a bolt 49 which extends between and is pivotally mounted in the platform disks 1 and 8. The bolt 49 is threaded throughout practically its entire length, the threads being removed however from one side of the bolt. A pawl 50 pivotally connected to the member 48 at the point 51 is adapted to engage the threads on the bolt 49 except when the flat side of the bolt is turned toward the pawl, as shown in Fig. 2. A helical spring 52 which surrounds the upper end of the bolt 49 normally holds the bolt with its flat side away from the pawl 50. A handle 53 extending from a collar 54 secured to the bolt 49 at its lower end forms a means by which the flat side of the bolt 49 can be turned to the pawl, as shown in Fig. 2, in which case the pawl will not engage the bolt. Suitable means for limiting the pivotal movement of the bolt 49 may be employed; these may comprise projections from the collar 54 which engage the upper projecting end of one of the bolts 11.

When, in a manner hereinafter explained, the rods 39 are moved upward until the upper end of the electrode 42 strikes the lower end of the tubular member 19, the sleeve 47 which slides loosely on the member 39 will at first be unaffected by the movement of the rods. After a certain movement of the rods however a collar 55 adjustably secured upon the left-hand rod 39, as seen in Fig. 1, will engage the lower end of the sleeve 47 and thereafter the sleeve 47 and the member 48 will move upward with the rods 39, the pawl 50 being constructed to automatically release its engagement with the rod 49 under these circumstances. When the rods 39 start to move downward however the pawl 50 will at once engage the rod 49, thus locking the sleeve 47 from movement. The downward movement of the rods 39 will end therefore when the

upper end of the sleeve 47 engages the under side of the cross-head 38.

As will be hereinafter explained, the arc length struck after each feeding operation between the end of the tubular member 19 and the end of the electrode 42 is thus limited to the play of the sleeve 47 between the cross-head 38 and the collar 55.

A pair of tubular magnet coils 56 have their upper ends secured to the under side of the disk or platform 1. The movable cores coöperating with these coils are connected at their lower end by cross-head 57. A rod or bar 58 adjustably connected to the cross-head 57 extends downwardly to a point adjacent the platform 9. A bushing 59 of insulating material extends from the platform 9 through an aperture formed for the purpose in the platform 8, and the lower end of rod 58 plays in the bore of this bushing. A pawl 60 of a clutch is pivoted to the rod 58 at the point 61. The yoke member 62 which coöperates with the pawl 60 surrounds the pencil 23. When the coils 56 are deënergized, the cores, cross-head 57 and rod 58 will drop down to the position shown in Fig. 1. In this position the pencil 23 will be free to move between the yoke and the pawl. When however the coils 56 are energized in the manner hereinafter described, the rod 58 will be elevated. This will cause the pawl 60 to first tilt and thereby lock the pencil 23 between it and the yoke and thereafter move the pencil upward. A layer of material 62′ such as mica insulates the pawl 60 and yoke 62 from the disk 8. Another tubular magnet coil 63 is secured to the under side of the platform 1 with its axis vertical. The core 64 of the magnet coil 63 carries at its lower end a disk 65 of carbon or other good conducting material. A pair of contact devices 67 and 68 are carried by or insulated from one of the posts 6 in such manner that portions 67′ and 68′, the upper surfaces of which are in the same horizontal plane, form stops against which the under surface of the disk 65 rests. When the coil 63 is deënergized, in this position, the contacts 67 and 68 are electrically connected by the disk 65. When however the coil 63 is energized the core 64 is raised and the disk moves away from the portions 67′ and 68′ thus breaking the circuit between them.

A tubular member 70 extends from the lower surface of the platform 9 to the upper surface of the platform or disk 1 passing through apertures formed for the purpose in the platforms 1, 8 and 9. The tubular member, which may be formed of metal, is surrounded by a layer 71 of material which is an insulator both of heat and electricity, and resistance conductor 72 may be wound about the outer surface of the layer 71. It will be observed that the tubular member 70 forms a chimney or ventilating pipe which leads from the space below platform 9 and discharges into the space between the disk 1 and the hood 5. The layer of heat-insulating material 71 serves to prevent the gases passing through the member 70 from heating the lamp mechanism. The air space between the plates 8 and 9 serves to prevent an undue transfer of heat from the chamber below the platform 9 to the lamp mechanism. To still further reduce the passage of heat, a layer 73 of suitable insulating material such as asbestos may be placed adjacent to the under side of the platform 9.

A cylindrical casing 74 surrounds the lamp mechanism located between the platforms 1 and 9. Apertures 75 and 76 located adjacent the lower and upper ends respectively of the casing 74 allow the ingress and egress respectively of suitable air currents for ventilating the lamp mechanism. A conical shell member 77, the lower end of which closely embraces the cylindrical casing 74 to which it is attached, extends upward and outward to engage the top member 5 of the casing. A horizontal screen 79 extends from the upper end of the conical member 77 to the casing 74. The casing 74 and the conical member 77 are also connected by an annular diaphragm 80 parallel to and located somewhat below the screen 79. Apertures 81 are formed in the member 77 between the diaphragm 80 and the screen 79. Apertures 82 are formed in the member 77 below the diaphragm 80 through which the air currents passing out of the lamp casing through the apertures 76 may pass. The gases passing upward through the member 70 discharge into the atmosphere through the apertures 81, the screen 79 serving to trap any bulky arc products or the like carried by the gases.

An annular member 85 closely embraces the edges of the disks 9 and 12. An extension of the member 85 below the platform 12 carries a series of nuts 86 through which screws 87 pass. The inner ends of these screws serve to support a globe 88 which surrounds the lower mechanism of the lamp. Openings 85′ formed in the member 85 admit air in proper amounts to the interior of the globe 88.

The circuit arrangements of the lamp may be understood by referring to the diagram shown in Fig. 3. Lines 89 and 90 connected to a suitable source, supply current to the lamp. A conductor 91 extends from the line 89 to one terminal of the resistance 72. The other terminal of the resistance 72 is connected to the disk 16. A conductor 92 connects the line 90 to one terminal of the coil 63. The other terminal of the coil 63 is connected to the lower electrode 42 of the lamp by a conductor 93. A conductor 94 connects the conductor 92 with the contact 67′. Contact 68′ is connected to one terminal of the magnet coil 30. The other terminal of

the magnet coil 30 is connected to one terminal of the coil 56. The other terminal of the coil 56 is connected to the pencil 23 through the cross-head 57, rod 58 and clutch carried at the lower end of the rod.

Assuming the initial out-of-service condition of the lamp to be that shown in the drawings; when the lines 89 and 90 are connected to the source of current, current will begin to flow between them to the conductor 91, disk 16, tubular member 19, pencil 23, coils 56, coils 30, contact 68′, disk 65, contact 67′, conductor 94, conductor 92. The passage of current through the coils 56 will cause the cross-head 57, and thereby the pencil 23, to be raised. As the lower end of the pencil 23 leaves the upper end of the projection 22, an arc will be drawn between them which will rapidly heat the lower end of the tubular member 19. The passage of current through the coils 30 will attract the cores 31 and thereby, through the rod 33 and clutch carried by it, raise the tubular member 36, cross-head 38, rods 39 and electrode 42 until the upper end of the electrode impinges against the lower end of the member 19. If for any reason the electrical conductivity of the upper end of the electrode 42 is sufficiently poor when the electrode is cold no current will pass between the electrodes 19 and 42 at the instant of contact. The poor conductivity of the electrode 42 when cold may be a property of the material from which it is originally formed, or it may be a property of the material into which the electrode or a portion of it is converted during the operation of the lamp. For instance, when the electrode is made of titanium carbid, which is a good conductor both cold and when heated, the action of the arc extending from the end of the electrode is to convert a layer or film of the titanium carbid at the electrode tip into one or more compounds of titanium, which are but poor conductors of electricity when cold though when heated the conductivity of these compounds is fairly good. In any event the heat generated in the lower end of the member 19 by the arc between it and the pencil or electrode 23 will be rapidly transferred to the upper end of electrode 42, soon raising its temperature to a point at which it becomes conducting. As soon as the tip of the electrode 42 becomes conducting, current will begin to flow between the lines 89 and 90 through the conductor 91, resistance 72, disk 16, member 19, electrodes 42, conductor 93, coil 63, conductor 92. The passage of current through the coil 63 will cause it to be energized, whereupon the armature 64 will move the disk 65 away from the contacts 67′ and 68′, thus breaking the circuit between them. When this occurs the coils 56 and 30 will both be deënergized. This will allow the cores of both sets of coils to drop down and thereby free both the pencil 23 and tubular member 36 from their controlling clutches. The downward movement of the pencil 23 will of course be limited by its engagement with the upper end of the projection 22. The downward movement of the electrode 42 will be limited, as has hereinbefore been described, by the engagement of the cross-head 38 with the upper end of the sleeve 47. As the electrode 42 moves away from the lower end of the member 19, an arc will be drawn between the two electrodes.

In order to prevent the formation of too long an arc between the electrodes 19 and 42, potential coil 95 may be connected between the line 93 and the disk 16 in shunt to the arc, as shown in Fig. 3. The core 96 of the coil 95 carries at its upper end a cross-head 97 of suitable conducting material. A spring 98 ordinarily holds the cross-head 97 and core 96 in the position shown in Fig. 3. When the voltage between the electrodes 19 and 42 rises beyond a predetermined amount, the core 96 will be pulled down by the coil against the action of the spring 98 until the cross-head rests upon a pair of contact devices 99 and 100. The contact device 99 is connected to the line 93 by conductor 101 while the contact 100 is connected to the conductor 94 by conductor 102.

When the cross-head 97 engages the contacts 99 and 100, it electrically connects these contacts, and a low-resistance shunt comprising the conductor 101, contact 99, cross-head 97, contact 100, conductor 102, and conductor 94 is thus closed about the coil 63. The coil 63 will then be deënergized and the disk 65 will connect the contacts 67′ and 68′, whereupon the coils 56 and 30 will be energized in the manner hereinbefore described and the electrode 42 will be moved into contact with electrode 19, after which a new arc of the length equal to the play of the sleeve 47 between the cross-head 38 and the collar 55 will be struck. Under some circumstances the coil 95 may be dispensed with. For this reason this coil has not been shown in Figs. 1 and 2 of the drawings.

The air currents produced by the heat of the arc pass upward through the cylindrical member 13 into the chamber formed between the platforms 9 and 12 from which they will pass through the tubular member 70, screen 79, and apertures 81 into the atmosphere. These air currents will serve to steady the arc and carry away the products of combustion formed by the arc.

While I have hereinbefore described the best form of my invention now known to me, I do not intend the claims which I have hereinafter made to be limited to the particular form described and illustrated further than is made necessary by the state of the art.

What I claim as new and desire to secure by Letters Patent of the United States is,

1. In combination, an electrode whose arcing end becomes a poor conductor when cold, a second electrode in proximity thereto and coöperating therewith to maintain an arc, and means for heating the second electrode to raise the temperature of the first-mentioned electrode and thereby increase its conductivity.

2. In combination, an electrode whose arcing end becomes a poor conductor when cold, a second electrode coöperating therewith to establish and maintain an arc, and means for bringing the arcing ends of said electrodes into contact with each other and heating the second electrode to increase the temperature and thereby the conductivity of the first electrode.

3. In combination, an electrode whose arcing end becomes a poor conductor when cold, a second electrode coöperating therewith to establish and maintain an arc, means for bringing said electrodes into engagement with each other, and means for applying heat to the second electrode until the current flowing between said electrodes reaches a predetermined value.

4. In combination, a non-consuming electrode, a consuming electrode in proximity thereto and coöperating therewith to maintain an arc, and means for heating the non-consuming electrode to thereby heat the consuming electrode.

5. In combination, a consuming electrode whose arcing end becomes a poor conductor when cold, a non-consuming electrode in proximity thereto and coöperating therewith to maintain an arc, and means for heating the non-consuming electrode to thereby heat the arcing end of the consuming electrode and increase its conductivity.

6. In an arc lamp, an electrode whose arcing end becomes a poor conductor when cold, a second electrode coöperating therewith to maintain an arc, means for producing a relative movement between said electrodes to bring their arcing ends into engagement with each other, and means for heating the said second electrode to increase the temperature and thereby the conductivity of the first electrode.

7. In an arc lamp, a consuming electrode whose arcing end becomes poorly-conducting when cold , a non-consuming electrode coöperating therewith to establish and maintain an arc, means for producing a relative movement between said electrodes to bring their arcing ends together, and means for heating the non-consuming electrode.

8. In an arc lamp, an electrode whose arcing end is of lower electrical conductivity at low temperatures than at high temperatures, a second electrode coöperating therewith to maintain an arc, means for producing a relative movement between said electrodes to cause their arcing ends to engage, and means for applying heat to said second electrode until the current flowing between the electrodes reaches a predetermined value.

9. In an arc lamp, a pair of electrodes arranged to coöperate to maintain an arc, the arcing end of one of said electrodes being poorly-conducting when cold, and means for heating the other of said electrodes when the electrodes are in proximity to each other.

10. In combination, a pair of main electrodes coöperating with each other to maintain an arc, an auxiliary electrode, and means for simultaneously moving the main electrodes into engagement with each other and for drawing an arc between one of the main electrodes and the auxiliary electrode.

11. In combination, an electrode whose arcing end becomes a poor conductor when cold, a second electrode coöperating therewith to form an arc, means for producing a relative movement between said electrodes to bring their arcing ends together, an auxiliary electrode, and means for maintaining an arc between said auxiliary electrode and said second electrode until the current flowing between the main electrodes reaches a predetermined value.

12. In combination, a main electrode in the form of a tube closed at one end, a second electrode coöperating with the main electrode to maintain an arc, an auxiliary electrode projecting into the bore of the tubular electrode, and means for drawing an arc between the closed end of the tubular electrode and the auxiliary electrode.

13. In combination, a pair of main electrodes, an auxiliary electrode, means for causing said main electrodes to be moved into engagement with each other and to separate so as to draw an arc, and independent means for starting an arc between one of said main electrodes and the auxiliary electrode.

14. In combination, a pair of electrodes coöperating with each other to maintain an arc, and means for directly heating one of said electrodes to indirectly heat the other.

15. In combination, a pair of electrodes coöperating with each other to start and maintain an arc between them, one of said electrodes requiring to be heated in order to make it operative for arcing purposes, and means for heating the other of said electrodes directly to indirectly heat the coöperating electrode.

16. An electrode for arc lamps consisting of a tubular shell of metal having one end closed and provided with an inwardly-extending projection at the closed end.

17. In an arc lamp, a threaded rod, an arc length limiting stop having a pawl carried by and moving with the support for the feeding

electrode and which engages the thread on the rod and locks the stop against movement in one direction, and means for moving the stop in the other direction at each feeding operation of the lamp.

18. In combination, a rod having one toothed side and one flat side, an arc length limiting stop having a pawl which normally engages said toothed side, and means for turning said flat side towards said pawl.

19. In combination, a tubular member or shell closed at one end, an electrode, one end of which projects into said tubular member or shell, a third electrode, and means for drawing an arc between one side of the end of said shell and one of said electrodes, and means for thereafter drawing an arc between the other side of the end of said shell and the other of said electrodes.

20. In combination, a non-consuming electrode in the form of a shell or tubular member closed at one end, a consuming electrode, the arcing end of which may become non-conducting when cold, means for moving the consuming electrode into contact with the closed end of the tubular member or shell, means for heating the interior of said tubular member or shell to thereby heat the end of the consuming electrode and increase its conductivity, and means for thereafter drawing an arc between the tubular member or shell and the consuming electrode.

21. In combination, a pair of main electrodes, an auxiliary electrode, means for moving said main electrodes into engagement with each other, and separate means for starting an arc between one of said main electrodes and the auxiliary electrode.

22. In combination, a main electrode, an auxiliary electrode normally in contact with said main electrode, a second main electrode normally out of contact with the first main electrode, and means for simultaneously moving the main electrodes together and separating the first-mentioned main electrode and the auxiliary electrode.

23. In combination, an electrode in the form of a tubular member or shell having one end closed and formed with a projection extending centrally and interiorly from said closed end, an auxiliary electrode extending into said tubular or shell member, and means for drawing an arc between the end of said projection and the end of said auxiliary electrode.

24. In combination, a metal electrode, a coöperating non-metal electrode, means for heating the metal electrode to thereby heat the non-metal electrode, and means for maintaining an arc between the electrodes.

25. In an arc lamp, the combination of a main cathode and an auxiliary cathode, an anode of good heat conductivity in arcing relation to both cathodes, and shielding the main cathode from the auxiliary arc.

26. In an arc lamp, a cathode that is a poor conductor of electricity in the cold state, an auxiliary cathode, and an anode that is a good conductor of heat in the cold state in arcing relation to both cathodes and interposed between them.

27. In an arc lamp, the combination of an anode of a material that is a good conductor of heat, a cathode that is a poor conductor of electricity in the cold state, and means for heating the cathode to conductivity by conduction of heat through the anode.

28. In an arc lamp, the combination of an anode that is a good conductor of heat interposed between a cathode which is a conductor of the second class and an auxiliary cathode, means for starting an auxiliary arc and thereby heating the main cathode by conduction through the anode, and means for starting an arc between the anode and the main cathode and breaking the auxiliary arc.

29. In an arc lamp, the combination of an anode of a material that is a good conductor of heat, a cathode which is a poor conductor of electricity in the cold state, an auxiliary cathode in arcing relation to the anode remote from the main cathode, and means for starting an auxiliary arc and thereby heating the main cathode to conductivity by heat-conduction from the anode.

30. In an arc lamp, the combination of a cathode that is a conductor of the second class, an auxiliary cathode, an anode that is a good conductor of heat interposed between them, means for starting an auxiliary arc whereby the main cathode is heated to conductivity by conduction through the anode, and means for starting the main arc when the main cathode has become sufficiently conducting.

In witness whereof I have hereunto set my hand this 26th day of February 1904.

JOHN T. H. DEMPSTER.

Witnesses:
BENJAMIN B. HULL,
HELEN ORFORD.