Nov. 26, 1935. S. RUBEN 2,022,219

ELECTRIC LAMP

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Fig. 1.

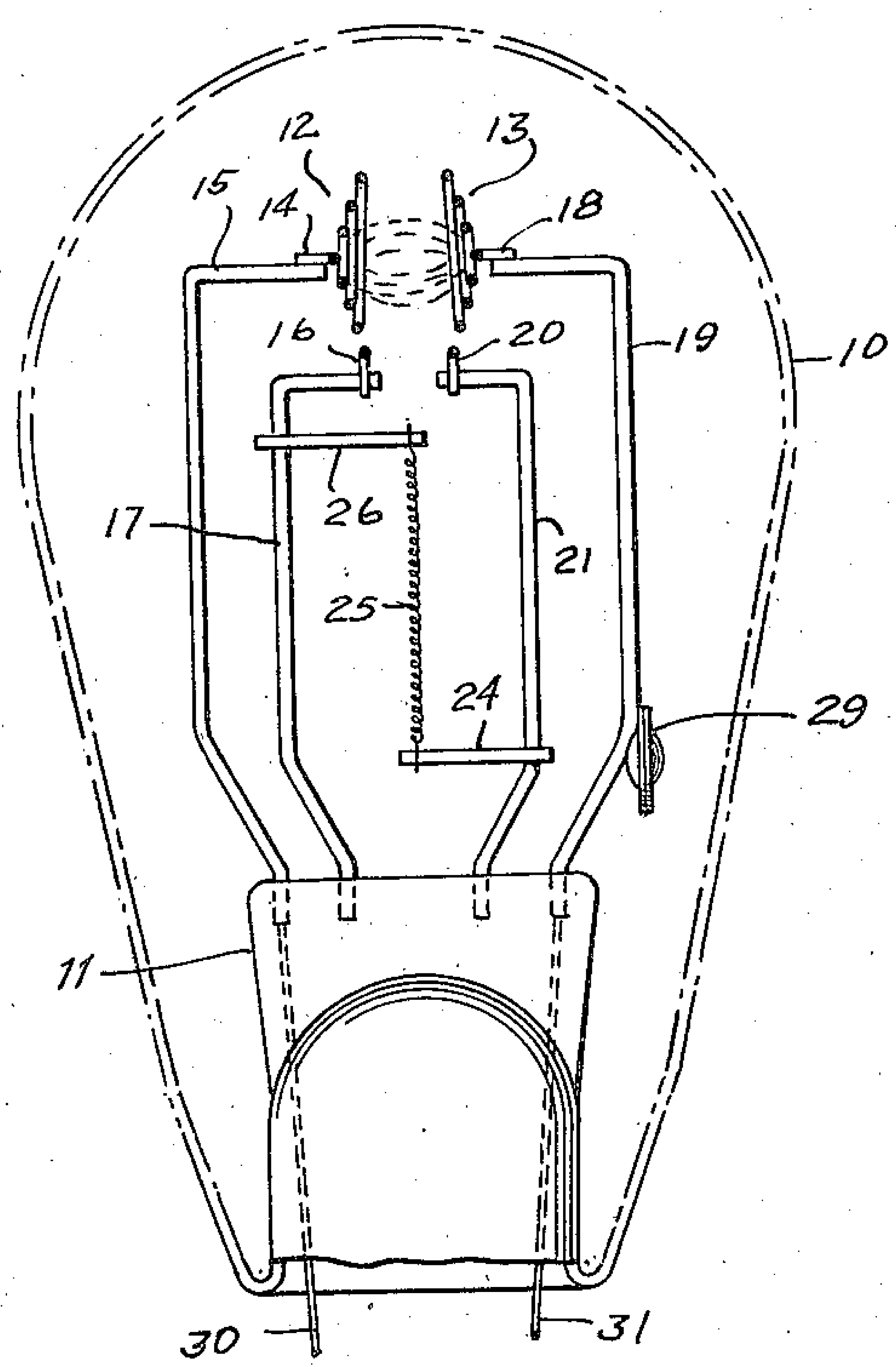


Fig. 2.

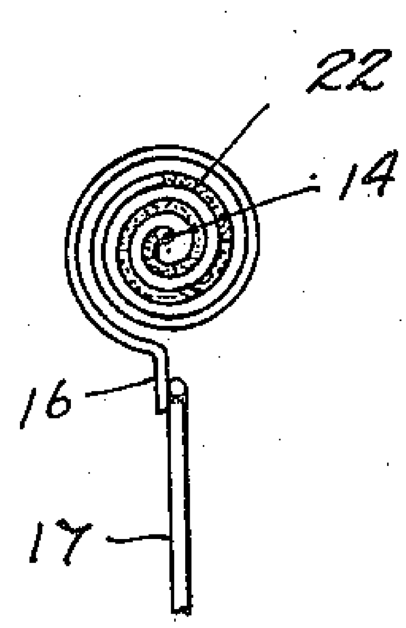


Fig. 4.

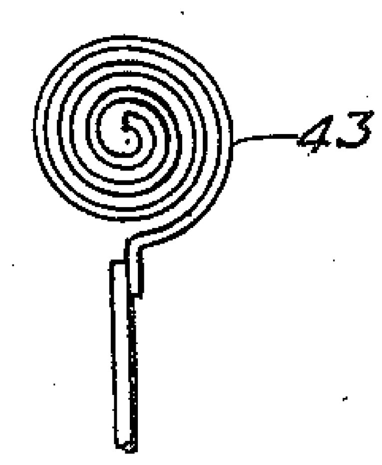
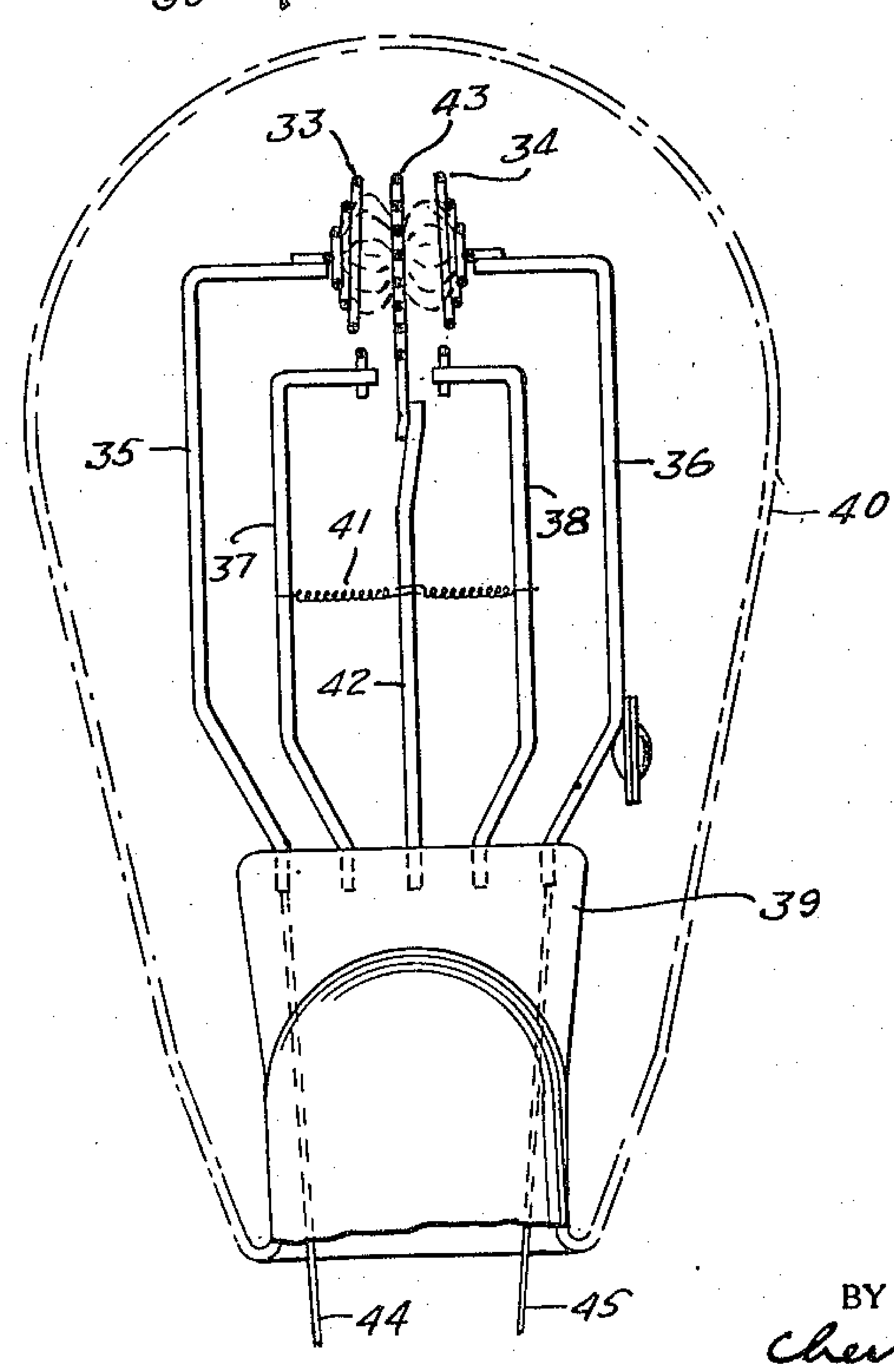


Fig. 3.



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ELECTRIC LAMP

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Fig. 5.

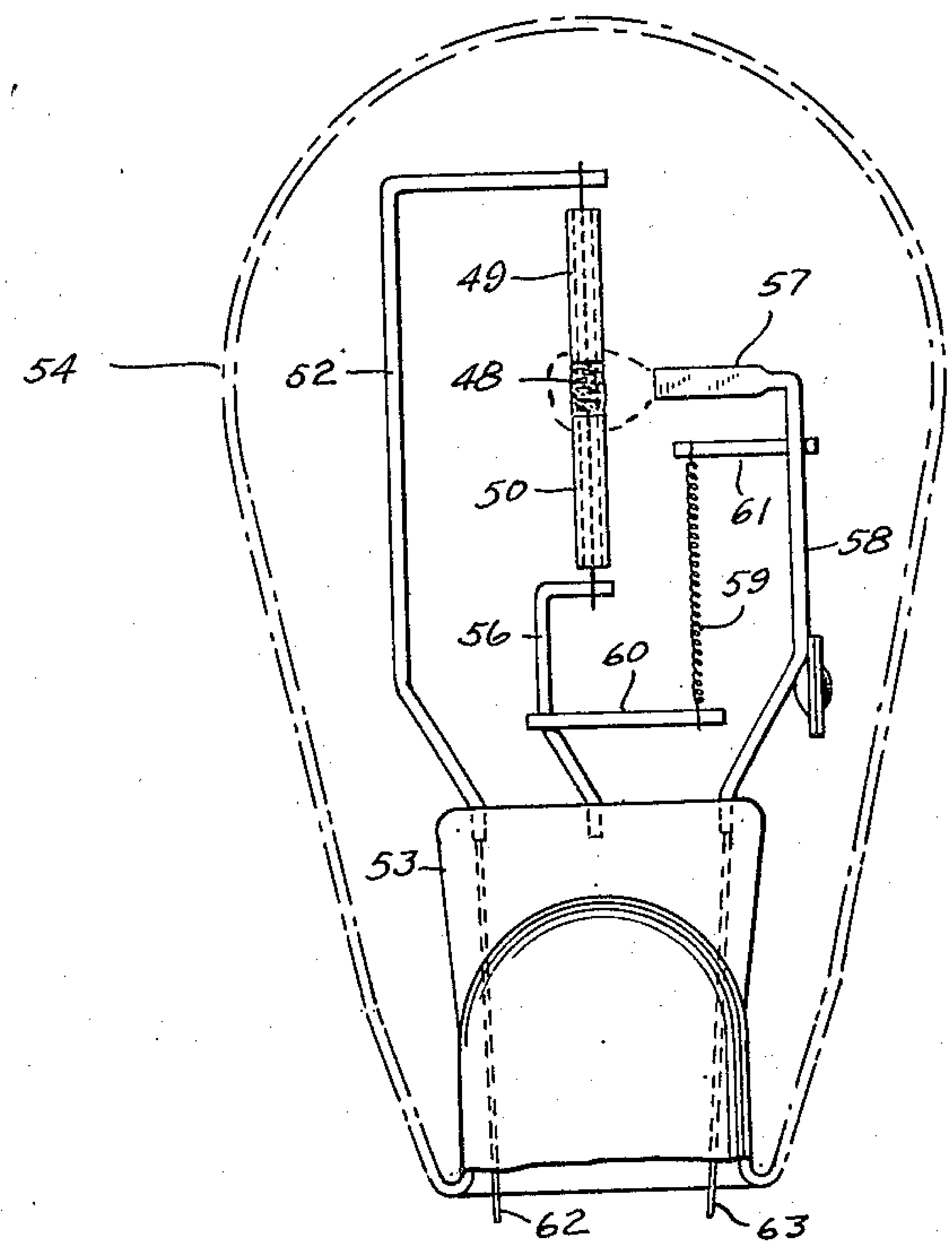

Fig. 6

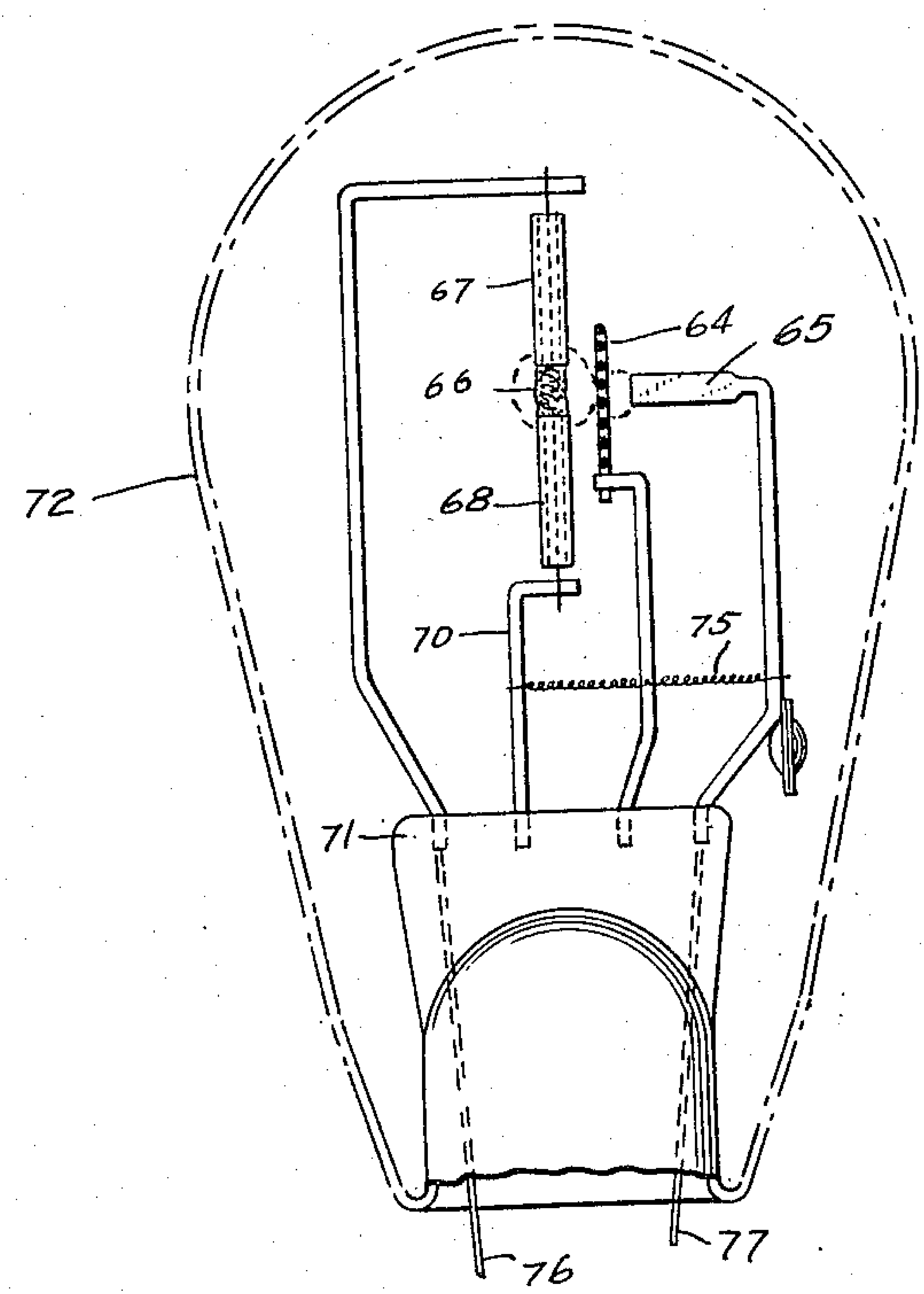

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Fig. 7.

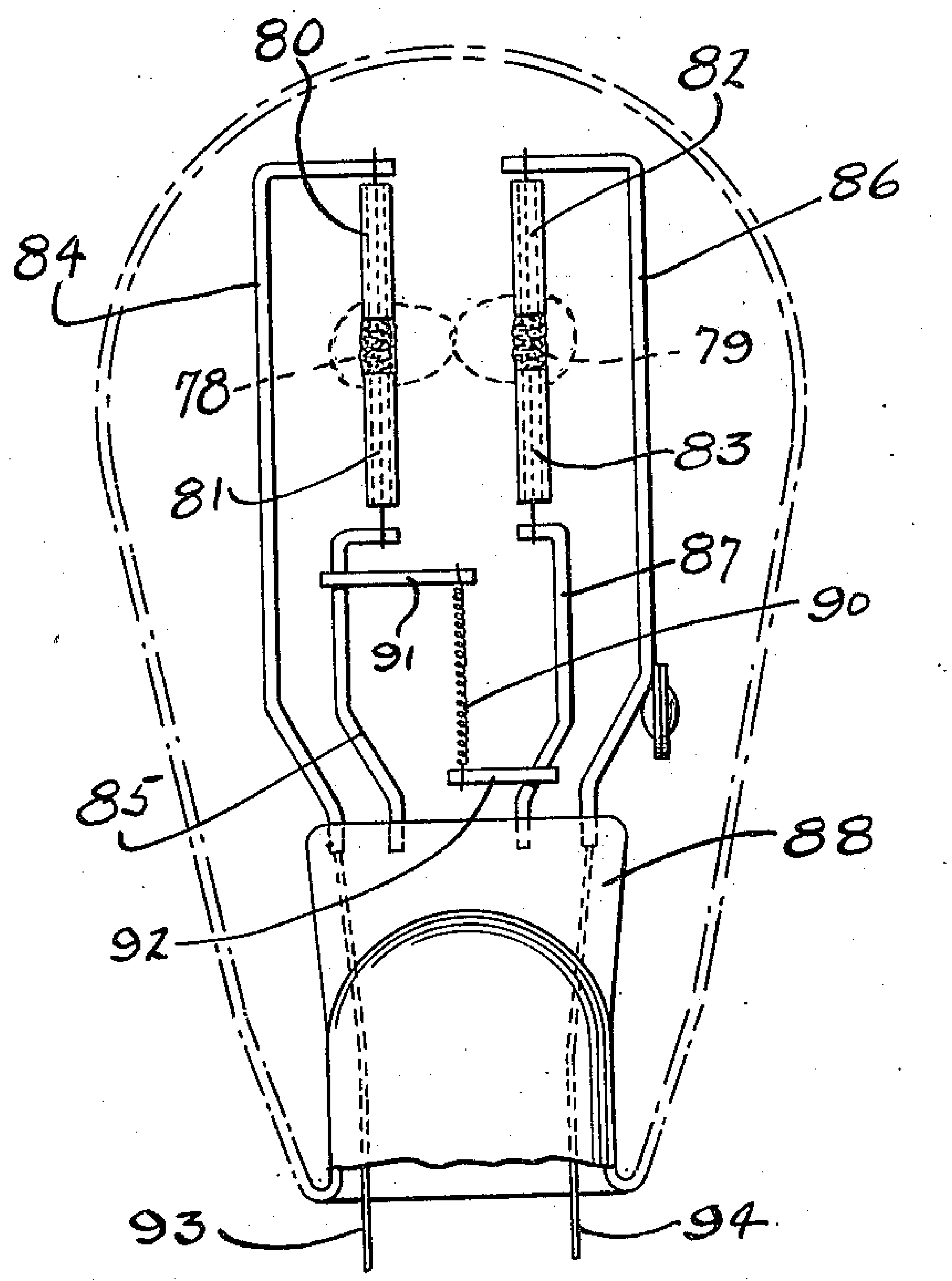
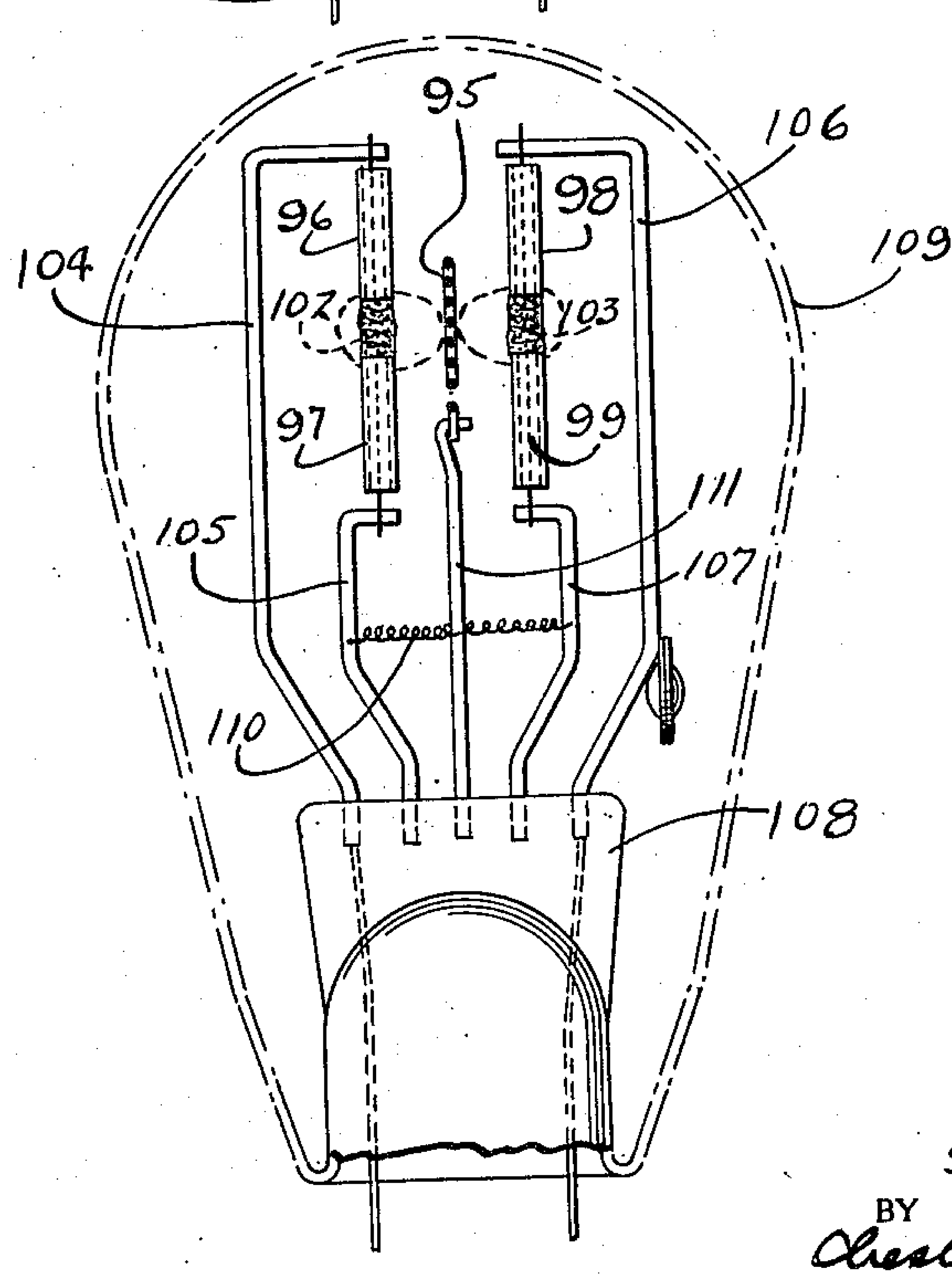


Fig. 8.



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UNITED STATES PATENT OFFICE

2,022,219

ELECTRIC LAMP

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Application July 24, 1930, Serial No. 470,387

8 Claims. (Cl. 176—1)

This invention relates to electric lamps and particularly to electric lamps having a gaseous atmosphere.

In attempting to obtain greater radiation efficiency from a heated body than can be obtained with a tungsten filament operating in a gas atmosphere various methods have been proposed in the past some of which are:

1. Reduction of vapor pressure of the tungsten.
2. Coating the tungsten with materials having selective emission.
3. Use of an arc.
4. Use of conduction through a material having electrical conductivity at high temperatures.

Referring to the first method, there are several apparent limitations to reducing the vapor pressure of tungsten. Materials having low vapor pressures are difficult to handle mechanically or chemically and if such materials are introduced into the tungsten prior to its fabrication they either change the character of the tungsten destroying its ductility, or due to the inert and crystalline nature of the material, they prevent the necessary working. Also in order to obtain any benefit from the reduction of vapor pressure of the tungsten by the addition of another material, the resultant mixture must be of a homogeneous character, and as the production of any compound with tungsten is limited to very small percentages, localized effects are had with no uniform distribution of the material in the resultant product, and while localized sections of a compounded filament might show less pressure effects, the practical result is nullified by the inactive areas of pure tungsten.

In order to obtain good effects with the second method, that of coating the tungsten with materials having selective emission, such materials must be uniformly distributed over the entire surface of the tungsten. The material must also be integral with the base and must not chemically unite with the tungsten with the highest temperatures otherwise it will lose its selective characteristics. The efficiency of a radiator increases exponentially with the temperature of the radiating body to such a high degree that the effect of increased temperature on a radiator is greater than that obtained by use of a coating. Materials having selective radiation also are poor heat conductors so that when applied to the surface of a tungsten filament the loss obtained due to the temperature drop between the filament surface and the outer surface of the coating is so great that the heat loss obtained is greater than the relative increase in efficiency. Another requirement is that the tungsten must operate at a higher temperature to overcome the temperature gradient of the coating. This induces chemical reaction such as reduction of the coated material with the tungsten surface and vapor and increases vaporization.

Another factor involved in coated filaments is that a binder is essential either in initial stages or in final reaction. In practically all cases the binder either reacts chemically with the base or coating or at the high temperatures volatilizes first and decreases the thermal efficiency due to less intra-crystal contact between the coating particles and the base.

The third method, that of using an arc, offers an opportunity for luminous intensities but is limited by certain undesirable characteristics such as maintenance of the arc by the electrodes. This involves consumption of electrode material, chemical reaction with the atmosphere, or physical reaction, such as occlusion and diminution of pressure by sputtered electrode particles or condensed vapor. It is also difficult to start an arc and in some cases the electrodes are brought close together and moved away from each other by a thermostat. If the arc is thus mechanically started by a thermostatic or other means, localization of current occurs with local effects such as vaporization, pitting and unsteady characteristics caused by varying discharge areas.

Low vapor pressure electrodes like tungsten, unaided, will not maintain an arc due to the external conductivity of the tungsten, and low vapor pressure thereof. Carbon in an inert atmosphere will not readily maintain an arc because the oxidation of carbon and carbon dioxide in an atmospheric arc light plays a large part in producing its illumination.

The fourth method, that of using a pyro-electrically conductive material as thorium or zirconium oxide has several disadvantages one of which is the electro-chemical instability thereof, or high temperature and current density electrolytic effects are had with change in performance of the radiator. Also due to the large mass necessary to allow the mechanical integrity large heat losses take place and the ratio of radiation surface to mass is low with resultant low efficiency. Relatively low melting and sublimation temperature of suitable materials lower the possible assistance obtained by the use thereof.

Another important limitation is that of negative resistance characteristics, for unless a resistance having a positive resistance coefficient is in series with the element to prevent the current from excessively increasing, unstable operation is had. As part of the measure load energy is dissipated in this regulating resistance a current occurs which reduces the operable efficiency.

It is therefore one of the objects of the invention to provide an electric lamp having all of the desirable possibilities of the above outlined methods of increasing radiation efficiency without any of the limitations mentioned and having a greater range and efficiency than lamps heretofore made.

Another object of the invention is to provide an electric lamp which will give a high degree of illumination with an electrical discharge or arc without deterioration of the electrode material.

Another object of the invention is to provide an electric lamp which will produce radiation from three separate sources, each operating at maximum and practical efficiency, namely, an intense ionic or distributed arc, radiation from a refractory surface maintained incandescent by ionic bombardment, and radiation in the usual manner from a metal filament.

Other objects of the invention and objects relating particularly to the method of preparing the various elements of the lamp and positioning them therein will be apparent as the description of the invention proceeds.

Several embodiments of the invention have been illustrated in the accompanying drawings in which:

Fig. 1 is a front elevational view of an electric light embodying the invention;

Fig. 2 is a side elevation of a portion of the device shown in Fig. 1;

Fig. 3 is a front elevational view of another embodiment of the invention;

Fig. 4 is a side elevation of a portion of the light shown in Fig. 3; and

Figs. 5, 6, 7, and 8 are front elevational views of other modifications of the invention.

Referring now more specifically to Fig. 1 an electric lamp is shown having the usual envelope **10** integral with the inturned press **11** for supporting the elements or parts of the light. Two spiral coils **12** and **13** of a refractory metal such as tungsten are wound in conical form and are mounted with the bases of the cones in substantially parallel spaced apart planes adjacent the center of the bulb. The coil **12** may have its center end **14** welded to a rod **15** which extends downwardly within the bulb being suitably bent to avoid other parts and is sealed in the press **11** while the outer end of the coil **16** may be welded to a rod **17** which extends downwardly substantially parallel to the rod **15** and is also sealed in the press **11**. In like manner the coil **13** may have its inner end **18** welded to a support rod **19** which extends downwardly in the bulb and is sealed in the press **11** and the outer end **20** of the coil may be welded to rod **21** which extends downwardly substantially parallel to the rod **19** and is also sealed in the press **11**.

The coils **12** and **13** may have one or two of their innermost turns coated with an electron emitting material as indicated at **22** comprising the oxides of barium, strontium, calcium, and the like or mixtures of these oxides so that electrons will be emitted from the innermost turns when the coil is heated by passing a current therethrough and these electrons will tend to bombard the outermost turns, raising these turns to incandescent temperature.

A short support rod **24** may be welded to the rod **21** adjacent the lower end thereof and may extend inwardly toward the center of the bulb and may have welded to it the lower end of a resistance coil **25**, which may be of any desired refractory resistance material such as tungsten, the upper end of which may be supported upon a rod **26** which may be welded to the upper end of the support **17**.

The envelope **10** is preferably filled with a gas and I have found if the high atomic number gases such as neon, argon, krypton, xenon, or the like are ionized with the addition of an alkaline metal vapor such as caesium or rubidium by electron bombardment, intense luminous effects are possible at commercial voltages. The higher the atomic number of the gas the nearer toward the visible part of the spectrum does the efficient radiation appear to be. A mixture of argon and caesium gives a yellowish-white discharge, but I may prefer to use krypton and xenon.

Care should be taken in manufacturing the lamp that all occluded gases and vapors are moved from the various parts thereof before sealing off the bulb. The bulb should preferably be heated in the usual oven while it is connected to the exhaust pump to draw out all gases and vapors that are in the bulb. This process should be carried on until no fluorescence is obtained when the bulb is subjected to high tension current from an induction coil and until a high vacuum of about .5 micron is obtained. The filament current is then turned on and the filament temperature raised slowly to drive out the binder for the emitting oxide and current is continually increased until the filament becomes a bright red at a temperature of about 800° C. The temperature of the oven is maintained at about 350° C. or as high a temperature as the glass of the bulb will stand and when no more gas is found the oven is removed and the filament heated to a temperature in the neighborhood of 1200° C. At this point I prefer to admit about ½ m. m. of neon into the bulb and a diffused glow then becomes apparent which fills the inside of the bulb. This appears to activate the emitting oxide on the filament and I prefer to maintain this condition for about ten minutes to be sure that all of the oxide is activated. The current on the filament is then still further raised for a short time until a temperature of about 1400° C. is reached and the neon gas is pumped out again, the pump being turned on until the high vacuum of about .5 micron is again obtained. The filament is then disconnected and the desired gases are admitted into the bulb to a pressure of about 200 m. m. of mercury. The bulb is then sealed off and may be ready for use.

The metal vapor may be introduced into the bulb by means of the small container **29** which may be made of two pieces of pressed metal, inclosing salts of the metals to be vaporized and having a pin hole therein through which the metal vapor may pass into the bulb when the container is heated in a manner well known in the art. The caesium vapor may be produced by combustion or reduction of a mixture of caesium chloride and magnesium which is placed in the container. When heated the caesium is ejected from the container and condenses on the walls of the bulb, and when the bulb is heated in operation the caesium vaporizes again and reduces the ionization potential of the gaseous mixture.

A leading-in wire **30** may be connected to the support rod 15, and another leading-in wire 31 may be connected to support rod 19.

In operation current flows through the wire 30, the supporting rod 15, the spiral coil 12, the supporting rod 17, the rod 26, the resistance coil 25, the support rod 24, the support rod 21, spiral coil 13, supporting rod 19, and out through the leading-in wire 31. This raises the temperature of the coil 25 to incandescence thereby producing light. At the same time the temperature of the spiral coils 12 and 13 is also raised sufficiently to cause the center coils thereof to emit electrons due to the rich electron emitting coating on the surface thereof. These coils preferably have such a resistance that the temperature thereof, due to the current flowing therein, will not be raised higher than the electron emitting temperature of the oxides used and the outer turns of the coils are additionally heated by bombardment of electrons from the inner turns causing the outer turns to increase in temperature to a point higher than they would normally be raised by the current flow, and producing incandescence and additional light radiation. The electron emission from the inner turns of the coils 12 and 13 also ionizes the gas in the region of these coils and an arc or discharge is formed between them producing a very bright intense light. The coil 25 is then in parallel with the arc and may act as a ballast to control it. The illumination therefor arises from three sources: the incandescence of the resistance coil 25, the incandescence of the outer turns of the coils 12 and 13, due to bombardment, and the arc which is formed between the outer turns of the two coils 12 and 13. It will be noted that the outer turns of the coils 12 and 13 protect the coated turns against ionic bombardment which might cause deterioration of the oxide surface thereon, the discharge taking place between the outer turns of the coils.

Where commercial power circuits are used, as for instance 110 volts, I have found that there is a tendency for current surges to take place, forming periods of increased arc between the coils 12 and 13 so that the light may not be steady, and to overcome this I prefer to reduce the voltage between the terminals of the arc. This may be done with the construction shown in Fig. 3 in which coils 33 and 34, similar to the coils 12 and 13, are mounted with their centers connected respectively to support rods 35 and 36 and the outer ends of the coils connected respectively to support rods 37 and 38, all of which rods are sealed in the press 39 which is formed integral with the envelope 40. Directly across between the support rods 37 and 38 I may place the resistance coil 41 which corresponds to the coil 25, shown in Fig. 1, and a center support rod 42 which is sealed in the press 39 may be connected to the center of the coil 41 and supports a flat spiral coil 43 (see Fig. 4) between the coils 33 and 34. Inasmuch as this coil 43 is connected to the midpoint of the resistance coil 41, the potential between the coils 33 and 43 will be half of the potential across the line, and similarly the potential between the coils 43 and 34 will be half of the line potential so that when the lamp is used in a 110 volt circuit the drop in potential between coils 33 and 43 and coils 43 and 34 will each be 55 volts which appears to prevent any current surges between the two outer coils, so that a steady light is produced. The temperature of the coil 43 is also raised by electron bombardment from the other coils and thereby aids in producing the light.

Leading-in wires 44 and 45 may be connected respectively to the support rods 35 and 36 and when the light is connected in a circuit current flows through leading-in wire 44, the support rod 35, the coil 33, the support 37, the coil 41, the support rod 38, the coil 34, the support rod 36, and out through the leading-in wire 45. In this case also the light is produced by incandescence of the filament 41, incandescence of the outer turns of the coils 33 and 34 and of the coil 43 by bombardment, and the arc through the ionized gas between the coils 33, 43, and 43 and 34.

In Fig. 5 a modification of the invention is shown in which a refractory filament 48, such as tungsten, is wound in a relatively short coil and the ends inserted through a pair of Nernst glower rods 49 and 50 which are positioned along a common axis. The end of the wire 48 which protrudes through the upper rod 49 may be connected to a support rod 52 which extends downwardly and is sealed in a press 53 formed integral with the bulb 54 while the end of the wire protruding through the rod 50 may be welded to a support rod 56 which may also extend downwardly to the press into which it may be sealed.

The glower rods 49 and 50 and the coil 48 may be mounted vertically in the bulb, if desired, and an electrode 57 which may be made of tungsten or other refractory metal or a refractory oxide may be positioned spaced a short distance from the coil 48 and at right angles to the axis of the coil and glowers. The electrode 57 may preferably be supported upon a support rod 58 which extends downwardly at one side of the bulb and is sealed in the press 53. Between the rods 56 and 58 I may position a coil of refractory resistance material 59 which may be made of tungsten, as in the constructions described above, and which may have one end welded to a short support rod 60 which is in turn welded to the support rod 56 and which may have the other end welded to a support rod 61 which may be welded in turn to the support rod 58. Leading-in wires 62 and 63 may be connected respectively to support rods 52 and 58, and when the lamp is connected in a circuit current flows in the leading-in wire 62, through the support rod 52, the tungsten filament 48, the support rod 56, the connector 60, the refractory resistance coil 59, the short support rod 61, the support rod 58, and out through the leading-in wire 63. The resistance coil 59 heats to incandescence and produces light, but the coil 48 which is coated with electron emitting material need only be heated sufficiently to cause electrons to be emitted therefrom. The electron emission from the coil 48 bombards the electrode 57 raising it to an incandescent temperature, and also ionizes the gas in the vicinity of the electrode and coil so that an arc is formed between the Nernst glower rods 49 and 50, which are heated to incandescence and conducting temperatures, and the electrode 57. Thus the light from the lamp is produced by the same three sources, namely, incandescence of the filament due to the flow of current therethrough, incandescence of the electrode by electron bombardment, and a gaseous discharge or arc.

In this case also where higher voltages are used it may be desirable to provide an intermediate coil and such a coil 64 is shown in Fig. 6 and is similar to the coil 43 shown in Fig. 3. This coil may be positioned between the electrode 65, which may be made similar to the electrode 57 already described, and the coil 66 which is coated with electron material similar to the coil 48. The Nernst glower rods 67 and 68 may be similar to those (49 and 50) already described in connection with Fig. 5, and the ends of the wire coil 66 passes through these glower rods 67 and 68 and may be attached to the support rod 69 at the upper end and to the support rod 70 at the lower end similar to the manner shown in Fig. 5, these rods extending downwardly and being sealed in the press 71 formed integral with the envelope 72. The electrode 65 may be supported upon the support rod 73 which extends downwardly and is sealed in the press 71. The coil 64 may be welded to a support rod 74 which is also connected to the midpoint of the resistance coil 75 and is sealed in the press 71. The coil 75, similarly to the construction shown in Fig. 5, may be connected between the supports 70 and 73. Leading-in wires 76 and 77 may be connected respectively to the support rods 69 and 73. This device operates similarly to the construction shown in Fig. 5 except that the potential drop between the coil 64 and the other parts of the device is half of the potential between the leading-in wires.

In Fig. 7 a modification of the construction of Fig. 5 is shown. In this case a pair of coils 78 and 79, coated with electron emitting material, are provided with extended ends over which Nernst glower rods 80 and 81 and 82 and 83 are positioned, these glower rods being on the axis of the coils as shown in the preceding construction. A support rod 84 may support the upper end of the coil 78 while the lower end thereof may be supported by a rod 85, and in like manner the upper end of the coil 79 may be supported by a support rod 86 while the lower end may be supported by a rod 87, all of which rods are extended downwardly and are sealed in the press 88 formed integral with the envelope 89, similar to the construction already described. A refractory resistance coil 90 may be connected between the two supports 85 and 87 by means of short support rods 91 and 92 which may be welded respectively to the rods 85 and 87 and which have the coil 90 between them. In this case, as in the construction of Fig. 5, the Nernst glower rods 80, 81, 82, and 83 are raised to incandescence by bombardment of electrons from the coated coils 78 and 79, the discharge taking place between the glowers in the vicinity of the ionized region adjacent the coils 78 and 79.

In Fig. 8 a modification of the construction of Fig. 7 is shown wherein a grid coil 95 is positioned between the Nernst glower elements. The Nernst glower rods 96, 97, 98, and 99 are mounted on the tungsten filaments 102 and 103 similarly to the construction of Fig. 1. The upper end of the filament 102 may be supported upon a support rod 104 while the lower end may be supported upon a shorter support rod 105. In like manner the filament 103 may be supported at its upper end by the support rod 106 and the lower end may be supported upon a support rod 107. All of these rods extend downwardly and are sealed in the press 108 which is formed integral with the envelope 109 as is shown in connection with the other constructions. A refractory resistance coil 110 may be welded between the two supports 105 and 107 and may be connected at its midpoint to the support rod 111 which may be sealed in the press 108 and may be welded to the helical or spiral coil 95. As in the construction of Figs. 3 and 6, the use of the intermediate grid 95 permits higher potentials with steady operation of the light.

In all of the construction described above it is preferred to have the gas pressure within the bulb sufficient to reduce evaporation of the incandescent tungsten parts and prevent discharges from the filament. It is to be noted again that the coil or concentrated tungsten filament which is used as a series or limiting resistance may also be efficiently used as a source of illumination by having a proper diameter and size.

Also in all of the construction described above the filaments should be so mounted and electrically shielded that ionization between them and other parts or the stem leads cannot occur.

In the construction shown in Figs. 5 to 8 inclusive, the Nernst glower rods are heated by electron bombardment from the coated coils, and inasmuch as these rods become highly conductive when hot and have a low cathode drop of potential, the arc preferably forms between them or discharges between the tungsten electrode and these rods in the constructions of Figs. 5 and 6. This raises the temperature of the surface of the rod to incandescence, and due to the selective emission qualities of the material out of which the Nernst tubes or rods are made, efficient radiation is obtained. The most important factor however is that the heating of the rods occurs at the outer surface and losses due to the temperature gradient caused by poor thermal conductivities are eliminated.

With these constructions using a metal vapor and a monatomic gas in the envelope, energy density far beyond that applicable to a solid refractory can be obtained with resultant radiation efficiency greater than that practically possible with refractory metals. Also the other elements, such as voltage reducing resistances, are used in another and full capacity, namely, as a source of light.

Many modifications may be resorted to without departing from the spirit of the invention, and I do not therefore desire to limit myself to what has been shown and described except as such limitations occur in the appended claims.

What I claim is:

1. An electric lamp comprising an envelope enclosing a coil of resistance wire having a portion thereof coated with electron emitting material, a second coil of resistance wire spaced from said first coil and having a portion thereof coated with electron emitting material, means to connect said coils in an electric circuit whereby a current may be passed through said coils to raise the temperature thereof, the coated portions of said coils being spaced farther apart than the uncoated portions.

2. An electric lamp comprising an envelope enclosing a coil of refractory metal wire having a portion thereof coated with electron emitting material, a second coil of refractory metal wire spaced from said first coil and also having a portion thereof coated with electron emitting material, the coated portions of said coils being farther apart than the uncoated portions, an ionizable gas surrounding said coils, and a third coil of refractory metal wire electrically connected between said first two coils but spaced therefrom.

3. An electric lamp comprising an envelope enclosing a coil of refractory metal wire wound in conical form, a second coil of refractory metal wire wound in conical form and spaced from said first coil with the larger turns adjacent the larger turns of the first coil, the smaller turns of both said coils being coated with electron emitting material, an electrical conductor having a sub-

stantial resistance interposed between said coils, and an ionizable gas surrounding said coils.

4. An electric lamp comprising an envelope enclosing a conical coil of refractory metal wire having the smaller turns thereof coated with electron emitting material, a second conical coil of refractory metal wire having its smaller turns coated with electron emitting material, said second coil being spaced from said first coil with the larger turns of both sides toward each other and in substantially parallel planes, and a resistance sufficient to maintain a gas discharge between said coils connected between the outer ends of said coils.

5. An electric lamp comprising an envelope enclosing a refractory metal coil, a second refractory metal coil wound in the form of a cone and having its larger diameter end electrically connected to one end of the first refractory coil but spaced therefrom, a third refractory metal coil wound in the form of a cone and having its larger diameter end connected electrically to the other end of said first refractory coil, an electron emitting coating upon a portion of the smaller diameter end of each of said conically wound coils, said conically wound coils being spaced apart from each other with the larger diameter turns adjacent and nearer to each other than the smaller diameter turns, and an ionizable gas surrounding said conical coils.

6. An electric lamp comprising an envelope, an ionizable gas within the envelope, two axially opposed and displaced electrodes having areas coated with electron emitting material, the uncoated areas being nearer together than the coated areas, and an electrical conductor having substantial resistance in circuit with said electrodes within the envelope.

7. An electric lamp comprising an envelope, an ionizable gas within the envelope, two axially opposed and displaced electrodes in coiled form with one end portion uncoated and the other portion coated with electron emitting material, the uncoated portions of the two coils being closer together than the coated portions, and an electrical conductor having substantial resistance connected to one of said coils.

8. An electric lamp comprising an envelope, an ionizable gas within the envelope, two axially opposed and displaced electrodes having areas coated with electron emitting material, the uncoated areas being nearer together than the coated areas, an electrical conductor having substantial resistance in circuit with said electrodes within the envelope, and an electrical conducting mass positioned medially in the line of discharge between said electrodes and connected to the midpoint of said resistance conductor.

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