Sept. 5, 1939. M. E. MACKSOUD 2,171,580

ELECTRIC LAMP

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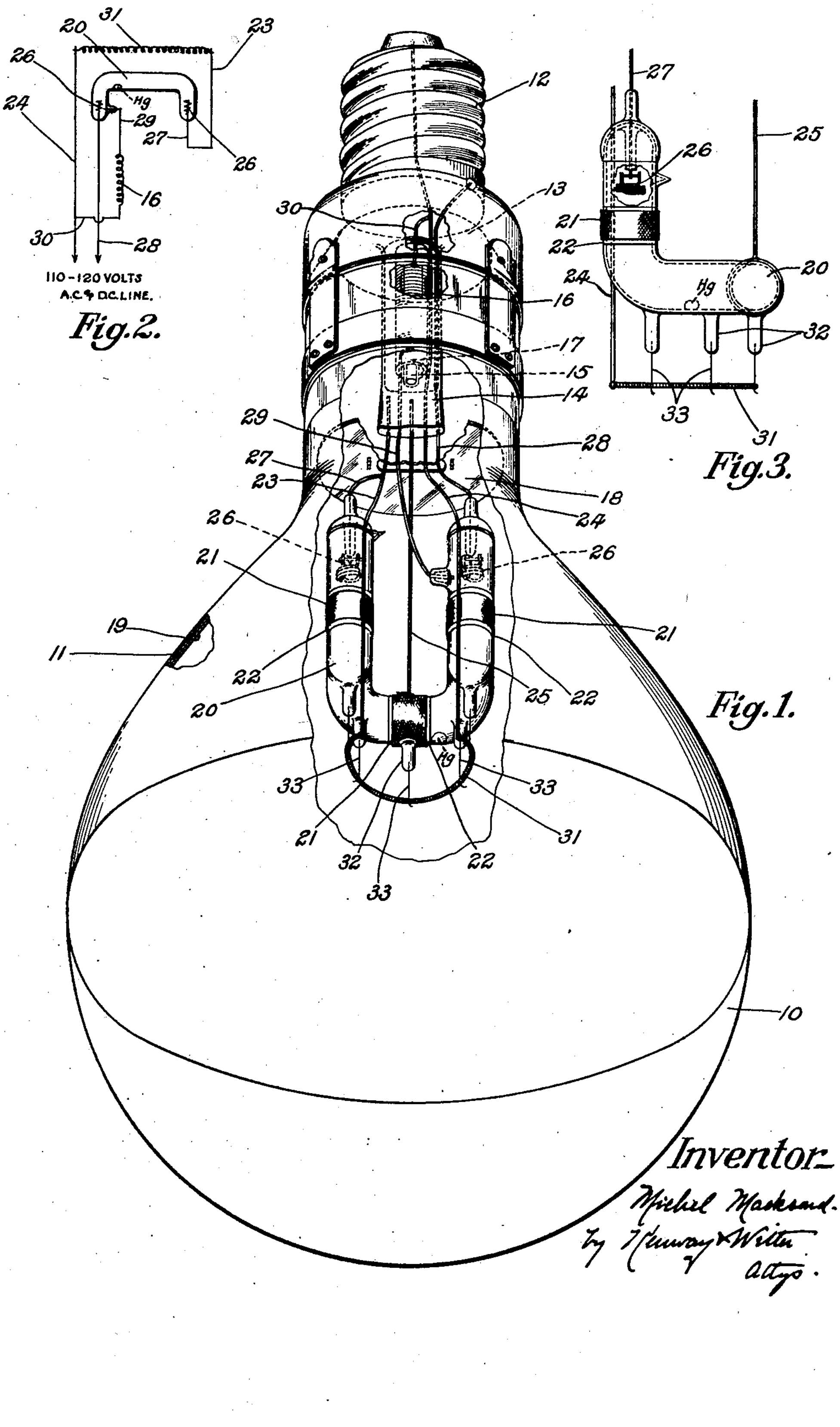

Inventor:
Michel Macksoud.
by Kenway & Witter
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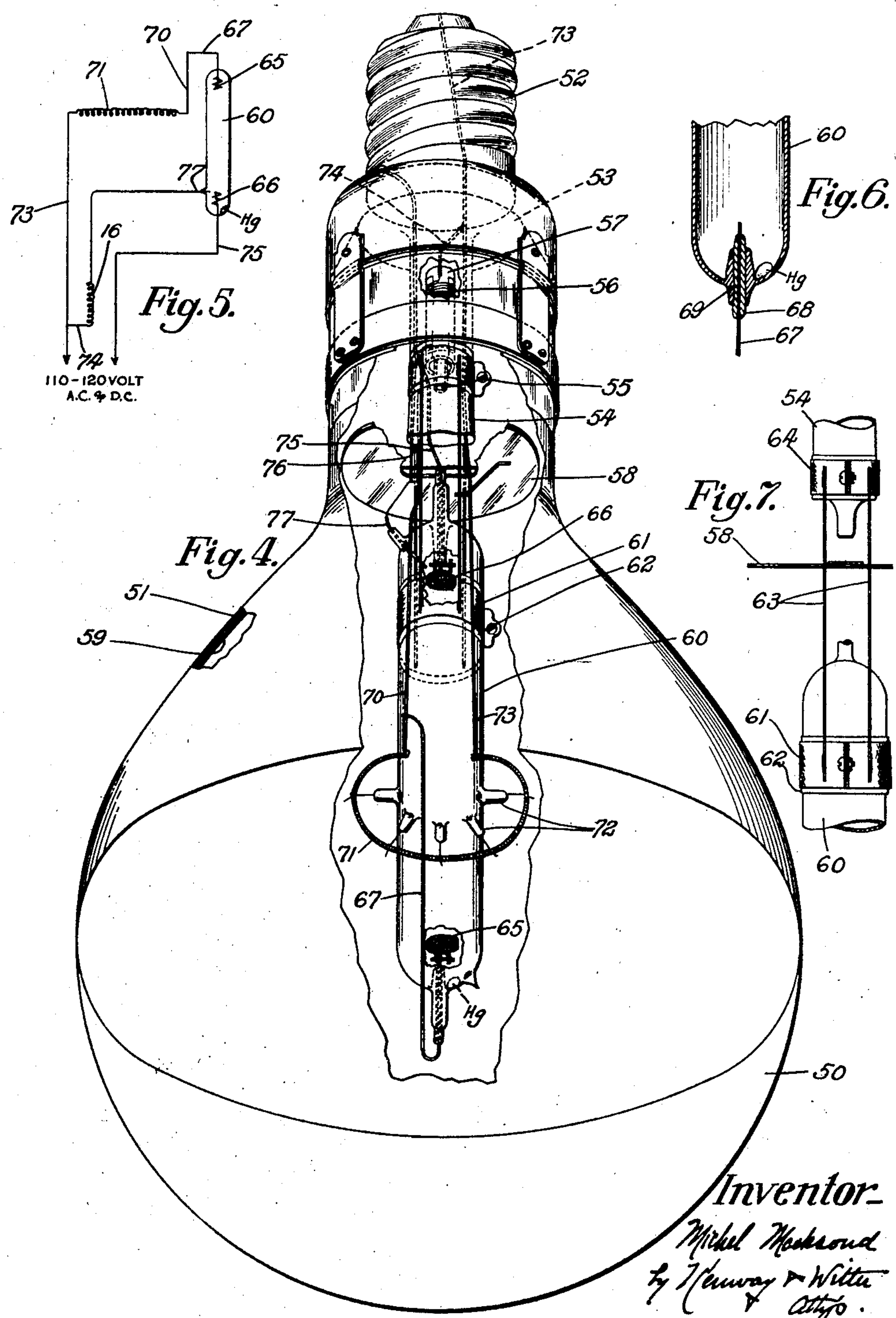

Inventor

Mikel Macksoud

by Kenway & Witter

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2,171,580

ELECTRIC LAMP

Michel E. Macksoud, St. Albans, N. Y., assignor to Macksoud Patents, Inc., New York, N. Y., a corporation of New York

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15 Claims. (Cl. 176—1.1)

This invention relates to electric lamps and, in one aspect, consists in a lamp containing in a unitary structure several light sources, each dependent upon the other for energization or control or both. In another aspect it consists in improvements in electric lamps of the type having a part of the surface of the enclosing bulb fashioned into a reflecting medium so that the light of the lamp is directed and concentrated in a predetermined beam or field.

One of the objects of the invention is to increase the efficiency of reflecting incandescent lamps by combining with an incandescent filament other sources of illumination within the same bulb enclosure, hooded and directed by the same reflecting surface, and energized directly or indirectly by the same current which heats the incandescent filament. The other sources of illumination may be arc discharge of one type or another, or may comprise fluorescent bodies or surfaces properly placed within the bulb and which become luminous and emit light of certain definite color in the presence of the otherwise wasted ultra-violet rays from either the arc discharge or the incandescent filament.

Another object of this invention is to make use of two or three different sources of illumination and different kinds of light, which may be of different and of predetermined colors, and of predetermined intensity, to produce a combined light that is closely identical in quality and spectrum range with daylight, or any other desired color or wave length range. For example, using a mercury arc and a tungsten filament, the former being distinctly blue and the latter yellow and almost complementary to the blue of the mercury arc, the spectrum of the light generated by each source may be so proportioned that the resulting combination will be close to daylight, or white light. Since the light generated by a high intensity mercury arc is much more efficient than the light from a tungsten filament, roughly 40 lumens per watt against 20 lumens per watt, it is desirable, from an efficiency standpoint, to use as much of the blue light from the arc as possible, and since this would tend to make the resulting combined light from the two sources too blue, as another important part of my invention, I contemplate correcting this too blue resulting light by adding more yellow light from another source, as for example, by using a fluorescent material which glows with a yellow light in the presence of the ultra-violet emitted by the mercury arc. Anthracene, eosine, escaline, fluorescein, naphalin, quinine sulphate, resorcin blue and rhodamin are suitable fluorescent materials that will act in this manner.

In general, an object of the invention is to produce a novel and greatly improved electric lamp for purposes of illumination, having a much higher lighting efficiency consistent with reasonable life than any other filament incandescent lamps now available on the market, and one which can be made to produce light having daylight characteristics as far as spectrum distribution is concerned or other predetermined spectrum characteristics if desired, the lamp having more than one luminous source all within the same enclosing bulb, hooded and the emitted light directed by the same reflecting surface, and energized by the same electric current.

The relationship between the position and shape of the light source and the shape and position of the reflecting surface, and therefore the actual shape of the bulb and of the filament or glowing unit containing the arc or other light source is of very great importance. Moreover, it is well understood that the smaller the light source, the nearer to a theoretical point source, the more accurately may the reflecting surface be shaped and proportioned to the light source and the more accurately will the light reflected by this surface be handled. Because of these considerations it is desirable to make the small bulb or tube containing the mercury or other arc of relatively small dimensions and to locate the filament as near to this small bulb or around its geometrical center as possible, so that the light may be considered as coming from the smallest possible source, thus bringing the total area or volume of the light source into proper relation to the reflecting surface designed to cooperate with it. In any case it is obvious that the light source can not be considered as a point source, for it has actual and substantial dimensions. This makes reflector design more difficult, although a fairly close approximation of the desired result is obtainable even with these relatively large light sources.

The reflecting coating is useful on a bulb of such a lamp in that it actually cuts down the heat loss from the arc-bulb, that is, for given conditions of operation, the temperature of the arc-bulb is higher with the reflecting coating than without it. This is an important consideration with small high temperature and therefore high pressure arcs, as is well understood by those well versed in the art. The use of the arc-bulb enclosed within a second bulb in which a relatively high vacuum is maintained serves to insulate the arc-bulb from the surrounding air, the only connection between the arc-bulb and the outside enclosing bulb being the necessary leads and wire supports. A reflecting coating hooding both the arc and the filament is a novel and important feature of the invention, valuable because it not only directs the emitted light rays in a predetermined pattern, but which also reflects part of the rays of both light and heat so that they fall on the arc-bulb itself, and so tend to raise its temperature. This method of reducing heat losses to the outside air from the arc-bulb increases the efficiency of the novel lamp of my invention.

The presence of the reflecting surface, and in this case preferably on the inside of the bulb, has made it possible to further increase the efficiency of this lamp by employing a fluorescent material on chosen areas of the inside of the lamp, which will glow in the presence of the ultra-violet light emitted in considerable amount by the arc source, and to a less extent by a high temperature incandescent filament. Since the ultra-violet light is emitted in all directions from the surface of the arc-tube and of certain filaments that may be used in conjunction with such an arc, it would be necessary to surround the combined light source completely with the fluorescent material, if it were desired to convert all of this ultra-violet light into visible light. Such an arrangement would not be desirable since these fluorescent materials do not transmit light readily, even when very finely divided, and are often entirely opaque. In a non-reflecting lamp in which it was desired to employ such opaque and semi-opaque fluorescent materials, it is obvious that wherever such a substance is applied to the surface of the enclosing bulb, for example, a reduction in transmitting efficiency will result. However, I have found that a light coating of finely divided fluorescent materials may be applied over the inside of that part of the bulb that acts as a reflecting surface without diminishing to the least degree the efficiency of the transmitting part of the bulb since there is no coating placed thereon, and without greatly reducing the reflecting efficiency of the reflecting portion of the bulb, since most of these finely divided materials are reasonably good reflectors, and some are very good reflectors. Thus the reflecting bulb not only serves to conserve and direct the light so that it is used more effectively, and to reduce the heat losses from both arc-tube and filament so that higher efficiencies are obtained, but it also makes possible the effective use of opaque and semi-opaque fluorescent materials on a large part of the bulb surface for the conversion of the invisible ultra-violet rays into visible light, with an appreciable increase in efficiency for the combined lighting sources. Such fluorescent materials may be placed on other parts of the inner surface of the lamp, or in some instances on its entire surface.

As has been pointed out above, the particular fluorescent material employed may be chosen so that the color of the converted light obtained will in part correct the color of the light from the other source or sources, so that daylight or some other desired spectrum range will be obtained. I have found satisfactory a relatively small cylindrical bulb or tube containing proper leads, electrodes, starting gas and vaporizable metal, and mounted within a larger reflecting bulb, with a filament either supported around the smaller bulb, or supported in a circle just below the smaller bulb. If it is desired to make the distance between the electrodes relatively great and thereby increase the voltage drop between these electrodes and thus increase the percentage of the total energy from the circuit used to generate the blue light of the mercury arc, for example, and of course at the same time reduce the percentage of energy used to heat the somewhat shorter filament and so decrease the total amount of the yellowish light from this source, I have found it desirable to use a longer cylindrical tube to enclose the arc. If a long tube for the arc is placed in relatively the same position as the short arc-tube it is necessary to employ a long external reflecting bulb to enclose the whole, and although such an arrangement is possible and a satisfactory reflecting surface can be designed to handle the light from this long slender cylinder, I prefer when employing such a long arc-tube, to shape the tube into a circle, open of course for a short space where the electrodes are sealed in.

It is believed that heretofore no electric lamp has been available which included in a unitary structure three sources of light as herein shown which may be given complementary characteristics in the production of a beam of selected light value as disclosed herein in accordance with the present invention. The utilization of ultra-violet light radiation from an incandescent filament to activate a fluorescent or phosphorescent material is also believed to be novel, as is also an electric lamp having a fluorescent source of light which is energized independent of external transformers and the like in a unitary lamp structure.

These and other features of the invention will be best understood and appreciated from the description of two prefered embodiments thereof, selected for purposes of illustration and shown in the accompanying drawings in which,

Fig. 1 is a view in elevation of a complete lamp, portions of the bulb being shown as broken away,

Fig. 2 is a circuit diagram of the lamp,

Fig. 3 is a view in elevation of the arc-tube and filament as seen at right angles from their position in Fig. 1,

Fig. 4 is a view in elevation of a complete lamp having a different form of arc-tube from that shown in Fig. 1,

Fig. 5 is a circuit diagram of the lamp of Fig. 4,

Fig. 6 is a fragmentary view on an enlarged scale of the lower end of the arc-tube,

Fig. 7 is a detailed view showing the manner in which the arc-tube is supported in the lamp.

The lamp of Fig. 1 is shown as comprising a bulb 10 of more or less conventional shape provided internally with a coating 11 of silver or other reflecting medium which extends continuously from a line in the neck of the bulb substantially to its line of maximum diameter. The bulb is provided with a threaded metal base 12 of usual construction and includes a hollow glass stem 14 having a flare 13 which is sealed to the bulb. At its inner end the stem has a flattened press in which the lead and supporting wires are sealed, all as in standard incandescent lamp construction. The bulb may contain argon, nitrogen or other inert gas and may have fluorescent material 19, such as eosine, naphalin etc. distributed over all or a portion of its reflecting coating 11. The arc-tube 20 has two upright legs joined by a substantially semi-circular portion and is supported by three nickel mesh rings 21, one encircling each leg and one encircling the semi-circular portion of the tube and all being insulated by mica collars 22. The rings 21 are preferably made in mesh form in order to interfere as little as possible with the emission of light from the tube and the glass of the tube is protected from excessive heat from them by means of the mica collars 22. The ring 21, which in Fig. 1 is located upon the left leg of the arc-tube, is connected by welding or otherwise to a supporting wire 23 which is sealed into the press of the stem 14. The ring 21 shown in Fig. 1 as located upon the right leg of the arm-tube is similarly connected to a lead wire 24 which is sealed into the press of the stem 14 and which is connected at its outer end to the insulated center terminal of the base 12. The ring 21, encircling the mid-section of the arc-tube, is connected to a dead supporting wire 25 sealed into the press of the stem.

A self-heating electrode 26 is sealed into the upper end of each leg of the arc-tube. In the preferred embodiment of my invention I employ main electrodes having the form shown in Figs. 1 and 3. A mandrel consisting of a straight length of wire with the arcing end wound into a few turns of a spiral from 1/8" to 1/4" in diameter is covered with a much finer wire wound in a spiral about the spiral part of the mandrel. The mandrel may be made of tungsten or other metal that will not melt at the operating temperature, and the finer wire wound on it may be of tungsten containing a relatively high content of thorium, or this fine wire may be of tungsten coated with barium or some similar metal. The purpose of this construction is to offer as much surface of highly emissive material as possible, and also to maintain a high ratio of such surface to the mass of the material being heated, so that the starting-up period is reduced to a minimum. The greater the mass of electrode to be heated the longer the delay between the first flash of the neon glow, and the final completion of the much longer mercury arc. Moreover, I have found it advisable to wind the fine wire on the spiral mandrel loosely, so that there is not a tight contact between the fine wire and the mandrel with the result that heat flows from the fine wire slowly, thus allowing it to become heated before the mandrel is heated. If the contact between the wires were tight, then they would both tend to be heated at the same rate, and the great capacity, relatively, of the mandrel would require a much longer time to arrive at starting temperature. To accomplish this desired result, I prefer to wind the coil of the fine wire on a different straight mandrel of slightly larger diameter, and then slip the coil thus produced onto and around the few coarse spirals of the mandrel proper. For example, I have found that the coil wound on a mandrel of 0.026 inch diameter, will fit properly and give the desired results, when it is slipped on the mandrel of the electrode when this mandrel is 0.20 inch in diameter.

In Fig. 1 the right hand electrode 26 is shown as connected to the lead wire 28 which passes through the press of the stem 14 and is soldered to the threaded metal base 12. The electrode in the left leg of the arc-tube is connected by a wire 27 to the supporting wire 23 above mentioned, the circuit to this electrode being completed through the filament 31 and the lead 24 as will be presently explained.

A starting electrode 29 is sealed into one side of the arc-tube at a point adjacent to the right hand main electrode 26. The wire of the starting electrode is sealed into the press of the stem 14 and is connected to the lower end of a resistance coil 16 which is wound upon a sleeve 17 of insulating material, such as lavite, and slipped telescopically upon the exhaust tube 15 which is sealed into the stem 14 and passes out of the bulb through the stem in the usual manner. In accordance with a feature of the present invention this exhaust tube is utilized as a support or mandrel for the resistance coil 16.

The end of the starting electrode 29 within the arc tube 20 may be coated with a material of high emissivity such as barium. The arc bulb contains a small amount of mercury and a small amount of an inert gas such as helium, neon, argon, krypton, xenon, or combination of these or other inert gases. The amount of mercury and the pressure of the inert gas determines the resultant pressure of the mercury vapor and its spectrum.

When current is turned on and during such interval before any arc forms, there is a potential drop between the starting electrode 29 and the adjacent main electrode 26 of the full line voltage. The neon, or other inert gas ionizes practically at once between the electrodes 29 and 26, the amount of current carried being small and the voltage across this arc being near the full potential of the line. As soon as the starting electrode 29 and some of the mercury in the arc tube 20 are heated even slightly a glowing arc of inert gas and mercury vapor is formed between the two main electrodes 26. A considerable current is carried by this arc which immediately reaches its full brilliancy. The neon glow disappears as soon as the temperature and pressure within the arc tube becomes too high for the impressed voltage. The mercury arc is established between the main electrodes 26 rather than across the shorter gap between the starting electrode 29 and its adjacent main electrode because the resistance of the longer path is much less than the resistance through the shorter gap and the high resistance of the coil 16 in series with the starting electrode.

A metallic reflecting disk 18 is located in the neck of the bulb in position to reflect rays which would otherwise be lost in the neck and thus to supplement the action of the reflecting coating 11 of the bulb. The disk 18 is perforated for the passage of the lead and supporting wires and an insulating panel of mica or the like is secured to the disk in registration with its perforation, for the purpose of insulating the lead and supporting wires from each other and from the disk.

A filament 31, which may comprise coiled tungsten wire, is supported beneath the circular portion of the arc-tube 20 in concentric relation therewith by means of a series of glass projections 32 extending downwardly from the lower surface of the arc bulb and connected to the filament 31 through tungsten hooks 33. As already explained one end of the filament is connected to the supporting wire 23 and the other to the lead wire 24 above referred to. The lower end of the resistance coil 16 is connected to the lead wire 24 by a connecting wire 30.

When the line current is applied to the lamp, the maximum line potential is impressed upon the electrodes 26, one connection comprising the lead wire 24, the filament 31, the supporting wire 23 and the wire 27; the other connection comprising the lead wire 28. Due to the presence of ionized gas at low pressure, the potential difference sets up a conductive path between the electrodes. The passage of current in this manner tends to heat the electrodes, to vaporize the mercury and build up the mercury pressure within the tube. The presence of mercury vapor reduces the resistance in the conductive path and permits the arc to strike and build up in intensity. When this occurs the filament 31 in series with the arc becomes incandescent due to the current flowing through it and its resistance effect becomes apparent so that the mercury vapor arc is limited in its current density by the resistance value of the incandescent filament. In other words the mercury vapor arc reaches a maximum intensity corresponding to the current which the filament 31 will pass.

Radiant energy generated by these sources, namely the filament 31 and the mercury arc, is now received by the fluorescent material distributed upon the inner side of the reflecting coating or on other portions of the bulb and this material consequently becomes a third light source within the bulb of the lamp. The action of the reflecting surface, besides defining the concentrated beam or field of the lamp, is in part to reflect radiant energy back upon the arc-tube 20 causing the mercury vapor to operate under conditions of high and uniform temperature with resulting increase in intensity of light supplied by the lamp. A further effect of the reflecting surface is to eliminate or reduce climatic changes which would otherwise effect the operation of the lamp. The temperature of the arc-tube is therefore maintained more uniform than would otherwise be the case, and the same is true as to its internal pressure and the character of its spectrum.

A second embodiment of my invention is illustrated in Figs. 4–7, the principal difference being that in the latter modification a straight arc-tube is employed instead of an arc-tube having a circular body portion of the character above described. Referring to Figs. 4–7 it will be seen that the lamp includes a bulb 50 having a silvered reflecting coating 51 extending from a point in the neck of the bulb substantially to the line of maximum bulb diameter. The lamp includes a metal base 52 and a hollow stem 54 having a flare 53 which is sealed to the bulb. The bulb tube 60 is supported below the end of the stem and is symmetrically placed in the main axis of the bulb. It is supported by a nickel mesh ring 61 insulated from the tube by a collar 62 of mica or the like. The collar 61 is connected by four supporting wires 63 to a ring 64 which is clamped upon the stem 54. A reflecting disk 58 of nickel or the like, located between the end of the stem 54 and the arc-tube 60, is perforated for the passage of the lead and supporting wires and provided with an insulating panel for them. An electrode 65 is sealed into the lower end of the tube 60 and a similar electrode 66 is sealed into its upper end. These electrodes include a coiled mandrel upon which is loosely wound a fine tungsten wire and may or may not be coated with an emissive material such as barium.

I have found that a satisfactory seal between the Pyrex or Corex glass of the arc-tube 60 and the metal of the electrodes may be accomplished, as indicated in Fig. 6, by first covering the wire with a close-fitting tube 68 of clear 705 glass and sealing the ends of this soft glass to the metal of the electrode. A second and shorter tube 69 of hard uranium glass is next fitted over the tube of 705 glass and sealed to it at the ends of the shorter piece uranium tubing. Finally the Pyrex or Corex glass of the arc tube itself is sealed to the hard uranium tube at near its central part. This seal has proved satisfactory and does not open in small cracks near the electrode, due to the high temperatures employed as I have found an ordinary simple seal to do.

The lead 67 from the lower electrode 65 is connected to a dummy supporting wire 70 which is sealed into the press of the stem. The wire 70 is connected to one end of a filament 71 which may be of coiled tungsten wire and arranged in the form of a circle concentrically about the arc tube 60. The filament 71 is supported and held in shape by tungsten hooks sealed into radially extending glass projections 72 on the outer walls of the arc tube. The other end of the filament 71 is connected through the lead wire 73 to the central insulated terminal of the lamp base.

The electrode 66, which is located in the upper end of the arc-tube, is connected by a lead wire 75 to the body of the base 52. Accordingly when the line voltage is impressed on the lamp the two electrodes are maintained at the full potential difference and when an arc discharge is established within the tube current flows through the filament 71.

A starting electrode 77 is sealed into the upper end of the arc-tube 60 so that it extends into a position adjacent to the upper main electrode 66. The starting electrode is connected through a wire 76 to the lower end of the resistance coil 56 already referred to and the resistance coil 56 is connected at its upper end through a wire 74, to the lead wire 73 and thus to the terminal of the base.

The bulb 60 contains a small amount of metallic mercury and is filled with argon, krypton, xenon or similar inert gases. Accordingly, when the line voltage is impressed upon the lamp, a glow discharge is immediately established between the starting electrode and the main electrode 66. The heating effect of this discharge and of the radiant energy reflected by the coating 51 warms the arc-tube as above explained, so that the mercury arc may strike, the filament 71 be raised to incandescence, and the fluorescent material caused to glow. The light from these three sources is blended, concentrated and directed by the reflecting coating of the lamp in a manner which will be understood from the foregoing description.

Having thus disclosed my invention and described two embodiments thereof, but without intending to limit it to the details of construction shown, I claim and desire to secure by Letters Patent:

1. An electric lamp having, in combination, a bulb provided with a reflecting surface, containing a filament and an arc tube with electrodes arranged in electric circuit with the filament, the tube being so located with respect to the reflecting surface as to receive reflected rays from the filament.

2. An electric lamp having, in combination, a bulb provided with a curved reflecting surface, a filament mounted within the bulb, and an arc tube located adjacent to the filament and to the focus of the reflecting surface, whereby light from the filament and arc tube is concentrated in a defined beam and rays from both sources are reflected upon the arc tube.

3. An electric lamp having, in combination, a bulb provided with a curved reflecting surface, an arc tube and a filament located within the

bulb and hooded by said deflecting surface, the filament being mounted adjacent to the arc tube in position to heat the same, and the arc tube being located in position to receive rays reflected by the reflecting surface of the bulb.

4. An electric lamp having, in combination a bulb provided with a curved reflecting surface, a filament, a mercury vapor tube mounted within the bulb hooded by the reflecting surface and arranged to receive heat rays therefrom, heater coils in said mercury vapor tube and a circuit connecting the filament in series with the heater coils.

5. An electric lamp having a bulb with an internal reflecting surface thereon, fluorescent material distributed upon said reflecting surface, and an arc-tube and a filament mounted within the bulb in position to emit radiation to said fluorescent material, the arc-tube being so located as to receive heat rays from said internal reflecting surface and the combined light from all three sources being concentrated in a defined field by said reflecting surface.

6. An electric lamp having a bulb with a reflecting surface thereon, an arc-tube mounted within the confines of said surface and having a circular body portion which is arranged substantantially concentric with respect to said reflecting surface to receive radiation therefrom, a filament mounted adjacent to said arc-tube and in concentric relation thereto, and serving as a source of radiation reflective by said surface to said body portion.

7. An electric lamp comprising a bulb having a reflecting surface thereon, an arc-tube having straight end portions and a circular portion located within the confines of the reflecting surface and symmetrically disposed with respect to the focus of the reflecting surface to receive radiation therefrom, said end portions being directed toward the neck of the bulb, a filament arranged concentrically with respect to the said surface and supported by the circular portion of the arc-tube, and serving as a source of radiation reflective by said surface to said circular portion.

8. An electric lamp for producing light of predetermined spectrum characteristics, comprising a bulb enclosing a high pressure, high temperature arc-tube, a filament in circuit therewith and fluorescent material dispersed over a part of the inner walls of the bulb, and a reflecting surface on the bulb shaped to hood said arc-tube and to blend, direct and concentrate the rays from all three sources in a defined beam.

9. An electric lamp comprising a bulb having a reflecting surface upon a portion of its wall areas, an incandescent light source within the bulb, and a relatively long arc-tube mounted within the bulb and having a circular body portion disposed symmetrically to the focus of said reflecting surface and arranged to receive maximum uniform radiation, reflected from said light source, by said surface, throughout its entire length.

10. An electric lamp comprising a gas filled outer bulb having reflecting wall areas, an incandescent light source within the bulb, an arc-tube of substantial length having a circular portion disposed with its axis in a plane at right angles to the main axis of the bulb and within the confines of said reflecting areas whereby the temperature of the arc-tube is increased by rays from said light source, reflected by said areas.

11. An electric lamp comprising an outer bulb having a reflecting coating upon a part of its area, an arc-tube having substantially parallel legs and an intermediate tubular portion curved on a circular axis and disposed concentrically within the coated part of the bulb, and a coiled filament supported adjacent to the arc-tube and substantially concentric with respect to its circular portion whereby the arc-tube may receive direct radiation from the filament, the reflecting coating acting to direct the combined light rays of the arc-tube and filament outwardly in a defined beam.

12. An illuminating electric lamp comprising a gas filled bulb, means within said bulb including a filament and gas ionizing electrodes for producing visible and ultra-violet light, means forming a reflecting surface within said bulb for the reflection of visible light from said means out from said bulb, and fluorescent material distributed upon said surface and exposed to ultraviolet light from said first mentioned means for producing additional visible light in said bulb for reflection by said surface from said bulb.

13. An illuminating electric lamp comprising a gas filled bulb, means within said bulb for producing visible and ultra-violet light, means forming a reflecting surface within said bulb for the reflection of visible light from said means out from said bulb, and fluorescent material distributed upon said surface and exposed to ultraviolet light from said first mentioned means for producing additional visible light in said bulb for reflection by said surface from said bulb, said first mentioned means including thermionic and gas ionizing electrodes.

14. An electric illuminating lamp comprising a gas filled bulb, means forming a curved reflecting surface upon a portion of the interior surface of said bulb, a filament mounted adjacent the focus of said surface for producing light for reflection by said surface, and an arc-tube mounted substantially in the focus of said surface for receiving reflected light in a concentrated beam therefrom, heat losses from said arc-tube being reduced by its enclosure in the gas in said bulb, by direct radiation from said filament and by reflected radiation from said surface.

15. An electric illuminating lamp having a bulb, a filament in said bulb for producing light, means forming a curved reflecting surface within said bulb for reflecting the light from said filament, and an arc-tube in said lamp substantially in the focus of said surface.

MICHEL E. MACKSOUD.