

May 10, 1938.

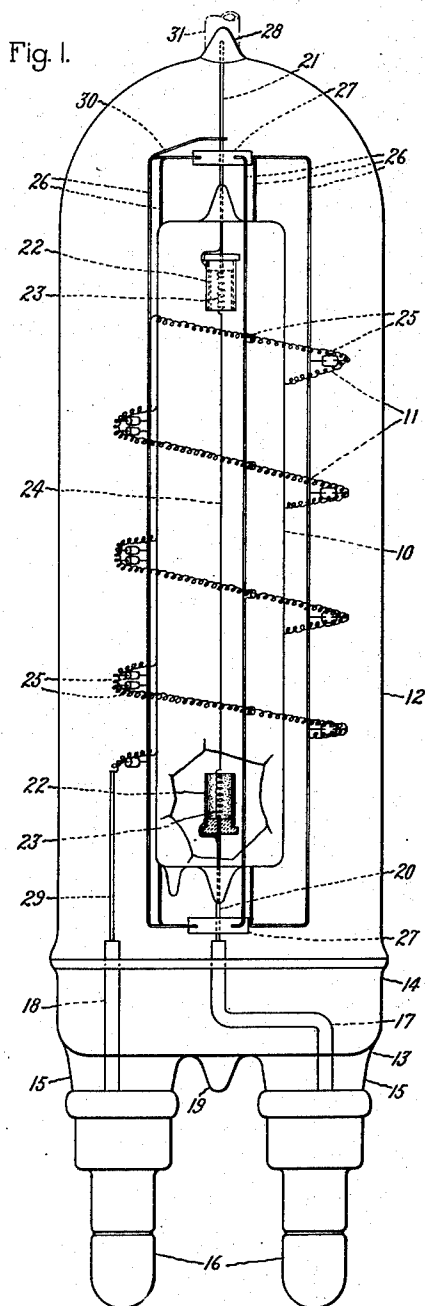
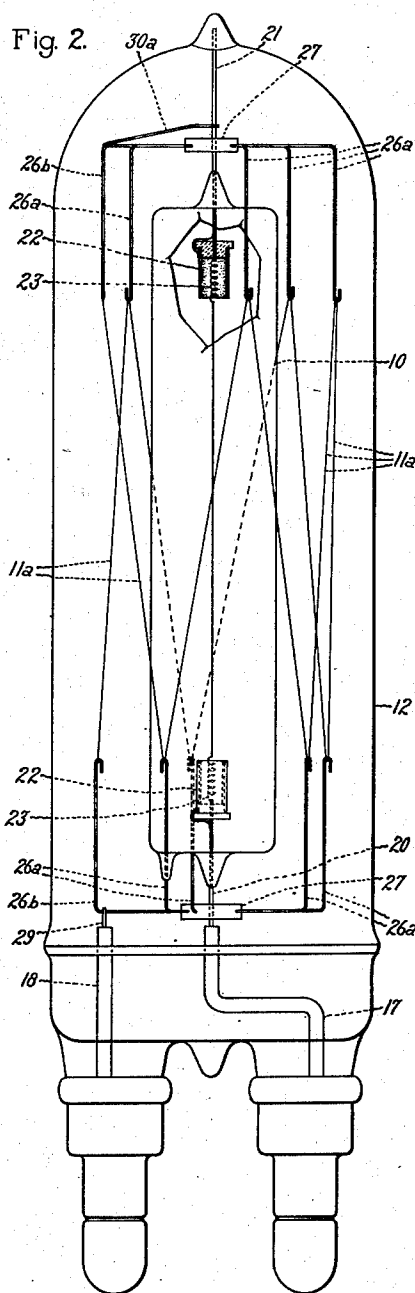
G. E. INMAN

2,116,681

ELECTRIC LAMP

Filed Sept. 15, 1934

2 Sheets-Sheet 1



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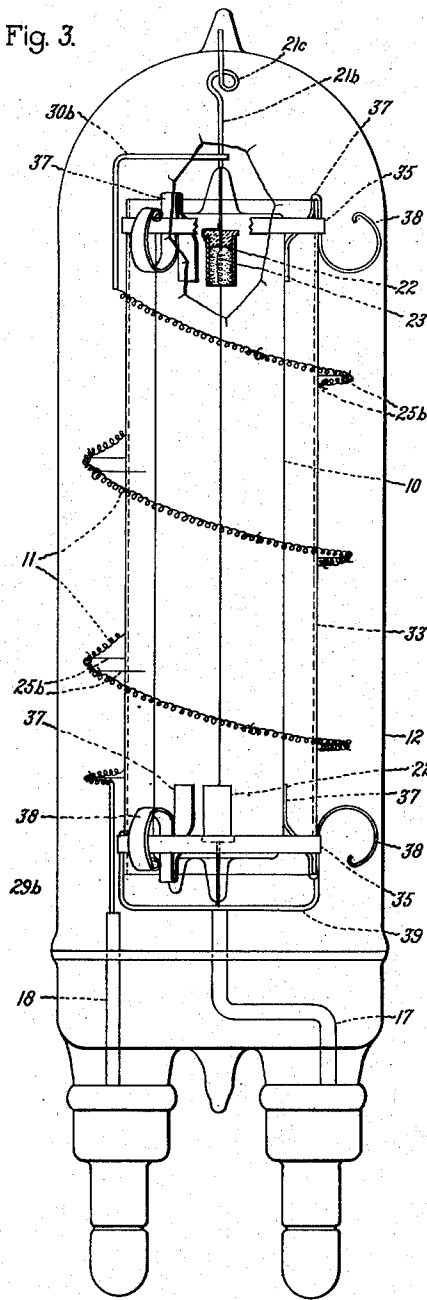
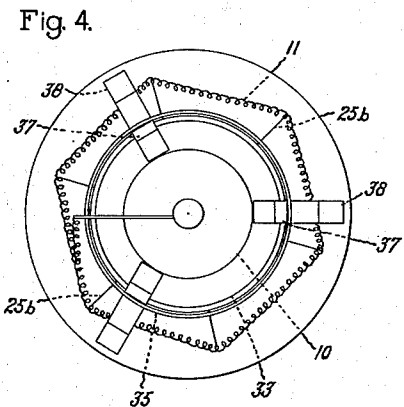
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UNITED STATES PATENT OFFICE

2,116,681

ELECTRIC LAMP

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15 Claims. (Cl. 176—1)

This invention relates to electric lamps and the like, and especially to glow discharge vapor lamps such as the so-called low pressure "positive column" type or the "cathodic glow" type, giving diffuse rather than sharply localized or intense concentrated luminosity. The invention is concerned with lamps that contain a vaporizable working substance,—e. g., sodium and some other metals,—and operate with very small vapor pressures of such substance. In such lamps, the absolute vapor pressure of the working substance is usually about 1 or 2 microns for sodium. Vapor pressures of low order are characteristic of the typical diffuse glow discharge, that generally appears to fill the whole lamp bulb. Very usually, such lamps contain a small amount of easily ionized gas, like neon, argon, etc., whose (partial) pressure in the lamp is around 1 or 2 to 7 mm., to assist in starting the sodium or other vapor discharge. This is the more desirable in lamps using a difficultly vaporizable working substance like sodium,—as contrasted with one that is much more easily vaporized like mercury.

Commercial sodium vapor lamps aim at operating temperatures around 250° C. for maximum efficiency; while the actual temperatures of their envelope or bulb walls range from about 220° C. or less to about 275° C. or more. The boiling point of sodium being about 877° C., the sodium vapor in the commercial lamp bulb is continually condensing on its inner surface and vaporizing again, with a tendency to accumulate and remain in any region or area that is relatively cool, because of the slower vaporization from the cooler region. This means that the sodium vapor pressure in the envelope will tend to fall below that corresponding to the general lamp temperature, and to approach that corresponding to the lowest temperature, i. e., that the lamp will virtually lack sodium, and its light output and efficiency suffer correspondingly. Or if the attempt is made to remedy this by forcing the lamp to operate at a higher current density in the glow discharge, and thus heat up its cooler region(s) to 250° C. or thereabout, then the general lamp temperature will be forced still higher, and the efficiency will also suffer.

Practically, it is very difficult to design a commercial lamp of the glow discharge type containing difficultly vaporizing metal so as to be evenly heated by its glow discharge; and the variation in wall temperature is apt to be even less favorable than the above-suggested range of 220° C. to 275° C. in the sodium vapor lamp.

While an adequate though small vapor pres-

sure of sodium or the like is essential to the operation of a glow discharge vapor lamp, and while the most favorable sodium pressure for efficiency is that corresponding to a (uniform) temperature of about 250° C., the current density in the glow discharge is also very important to the efficiency, and in a contrary sense, i. e., the lower the current density, the greater the luminous efficiency of the glow discharge. However, glow discharge currents that would be highly favorable from this point of view are insufficient to heat the lamp to the temperature that is most favorable as regards vapor pressure of a working substance such as sodium. This is so even when the sodium vapor lamp is operated in a double-walled vacuum jacket in order to conserve heat, as is customary.

Other limitations and drawbacks of such vapor lamps have lain in the necessity of a ballast resistance in series with the lamp, to control and limit the rise of current through the lamp as it heats up; and of either providing compensating resistances, reactors, or transformers to allow such lamps to operate in parallel on ordinary (alternating current) lighting circuits of 110-120 volts, or else operating a plurality of the lamps in series.

I have found that these difficulties can be overcome, and a very high operating efficiency realized in a lamp of this general type, by supplying additional heat as uniformly as possible and as nearly according to the deficiency in the various parts of the lamp as possible, so as to maintain a proper uniform lamp temperature with a relatively low glow discharge current, or current density. Preferably, and as hereinafter described, the lamp is heated externally. Suitable electrical heating means for this purpose may be operated independently from a separate heating circuit, or may be adapted and used to ballast the lamp, or may be used to compensate for its low operating voltage. Useful light may be obtained from an incandescent body as well as heat; and the enhanced luminous efficiency of the glow discharge will make up for relatively poor luminous efficiency of such a filament. I have here particularly illustrated and described my invention as applied to a glow discharge lamp of cylindrical or tubular form enclosed with the external heating means in a cylindrical or tubular evacuated outer envelope; but while the cylindrical or tubular shape lends itself very advantageously to my purpose, it is not essential, and the invention in its broader aspects can be adapted to other

shapes of glow discharge lamp and outer envelope.

I aim, furthermore, to provide light of improved quality by combining different light color tones produced in the glow discharge lamp by two or more different ones of such working substances as sodium, potassium, or other alkali metal, or mercury, cadmium, calcium, or magnesium, etc.; also by combining the light of solid filaments or glow bodies with glow discharge vapor lamp light. Either or both of these measures may be employed in lighting units such as referred to in the preceding paragraph.

Various other features and advantages of the invention will appear from the following description of species thereof, and from the drawings.

In the drawings, Fig. 1 is a side view of a lamp unit embodying my invention; Fig. 2 is a similar view of another form of lamp unit also embodying the invention; Fig. 3 is a side view of still another form of lamp unit embodying the invention; and Fig. 4 is a plan view corresponding to Fig. 3.

The device shown in Fig. 1 comprises an elongated, tubular glow discharge vapor lamp 10 surrounded by filamentary heating means 11 arranged to coact with the internal heat of the lamp in heating the lamp envelope walls uniformly substantially throughout their extent, from end to end of the lamp. In this particular instance, the heating means 11 extends around and around the lamp 10 in a multiplicity of suitably separated turns, and consists of a single continuous finely coiled filament, itself coiled or wound in a suitable large "tubular" spiral or helix. The lamp 10 and filament 11 are enclosed in an evacuated and sealed (glass) envelope or bulb 12, of an elongated, tubular form, which not only protects the filament from the atmospheric oxygen, and mechanically protects the filament and the lamp, but also minimizes radiation and loss of heat from the lamp, as well as from the filament,—thus conserving the heat to keep the lamp envelope hot. The filament 11 is preferably of material having a positive temperature-resistance coefficient, particularly tungsten.

Preferably the lamp 10 and its surrounding filamentary heating "tube" 11 (so to term it) are arranged coaxially with one another and with the bulb 12. In the present instance, the device is shown equipped with a unitary base and contact terminal structure 13 which in effect forms part of the outer envelope 12 itself,—rather than with a separate base secured to an envelope complete in itself, apart from the base. This structure 13 comprises a cup-like body 14 of glass with downward-projecting hollow nipples 15, 15 to which are fused hollow metal terminal posts or thimble-sleeves 16, 16, closed at their lower ends. Such a unitary contact terminal structure is commonly known in the art as a "bi-post base". Metal current leads 17, 18, preferably of channel section, are attached to the hollow contact terminals 16, 16 inside the latter, and extend up through the nipples 15, 15 into the cup-like body 14. There a lead 17 is offset (by double bends) to the center or axis of the envelope 12. The exhaust tip 19 on the glass body 14 is also shown sealed off.

The lamp 10 is mounted on the central lead 17 and supported by it, and may be additionally supported or steadied by engagement or connection with the other end of the outer bulb 12, as described hereinafter. The lamp 10 here shown has

an all-glass envelope with current leads 20, 21 centrally sealed through its opposite ends and connected to the axially arranged glow-discharge electrodes 22, 22, which are preferably of an indirectly heated type such as known in the art. The electrodes 22, 22—or, more properly speaking, their internal (axial) heating resistances 23, 23—are interconnected by an axially extending (molybdenum) lead wire 24. These particular electrodes 22, 22 are of internally emissive hollow type; i. e., each of them has its electron-emissive material (such as barium oxide) on the inner surface of a (nickel) tube that is open at its end toward the other electrode.

It is not preferable to wind the filament 11 directly on the lamp tube 10, but rather to support the filament out of contact with the lamp tube, as by a series of (insulative) anchorage supports 25, whose free ends have pigtail eyes or hooks to take the coiled filament 11. Each anchor 25 may consist of wire sections fused into an insulating (glass) bead. As shown, the supports 25 are not attached directly to the lateral walls of the lamp envelope 10, but to a supporting spider cage structure or frame surrounding the lamp, and consisting of (five) wires 26 paralleling the envelope walls a little outside them and having their upper and lower ends bent inward beyond the lamp ends and fused into central insulative (glass) buttons 27, 27. These buttons 27, 27 may be supported by upper and lower current leads 20, 21 of the lamp 10, which are shown as fused through said buttons 27, 27 and insulated by the button material from the wires 26. The lower lamp lead 20 is mechanically attached and electrically connected to the upper end of the central base terminal lead 17, and the upper end of the upper lead 21 may be fused and sealed into a tip 28 on the (hemispherical) upper end or bowl of the outer bulb 12,—which may be formed like an old-fashioned incandescent lamp exhaust tip. The lower end of the filament 11 is shown welded to a short wire 29 itself electrically connected to the base terminal lead 18, and the upper end of the filament is shown welded to one of the spider-structure wires 26 at its upper inward bend. The filament 11 surrounds and heats the lamp 10 substantially throughout the extent of its lateral walls excepting only at the ends, around the electrodes 22, 22, where it receives ample heat from the electrode heaters 23, 23 and the glow discharge.

While the filament 11 and the discharge gap between the electrodes 22, 22 of the lamp 10 might be connected in parallel so far as the heating function of the filament 11 is concerned, there are important advantages in connecting them in series, which is done by means of a lead wire 30 welded to the upper lamp lead 21 and to the upper inbent portion of the same wire 26 to which the upper end of filament 11 is welded. Thus the (tungsten) filament 11 ballasts the lamp, and may also increase the over-all resistance of the lamp so as to enable the lamp to be operated on standard lighting circuit of around 110 to 120 volts.

In manufacture, the filament system 27, 26, 25, 11 is built around the lamp 10, and then this filament and lamp assembly is installed on the base structure 13 and electrically connected thereto at 17 and 29. The thus-completed "mount" is introduced into the bulb 12 with its upper lamp lead 21 extending into a tubulature 31 (like an old-fashioned incandescent lamp exhaust tubulature) that is shown in dot and dash lines in Fig. 75

1. After sealing the bulb 12 to the base 13, the tubulature 31 is fused down and sealed around the lead wire 21 as shown in full lines at 28 in Fig. 1.

5 In the operation of the device, starting cold, the current flows at first through the electrode-heating resistances 23, 23, their lead 24, and the filament 11 all in series; but as the electrodes 22, 22 heat up, more and more current is carried by ions of the neon or other gas in the gap between them. As the whole lamp 10 heats up and vaporizes some sodium or other metal, the metal ions participate in the luminous discharge,—in shunt with the resistances 23, 23 and lead 24, but 15 still in series with the filament 11. Besides being internally heated by its electrode-heaters 23, 23 and its glow discharge, the lamp 10 is externally heated by the filament 11 surrounding it. The vacuum in the envelope 12 minimizes loss of heat 20 by conduction or convection. The efficient external heating of the lamp 10 by the filament 11 helps to vaporize the sodium or other such working substance in the lamp. In other words, the heating means 11 coats with the glow discharge 25 and the electrodes in heating the walls of the lamp 10 uniformly to a temperature sufficient to maintain an ample supply of the metallic vapor with a low glow discharge current density. This gives very much greater luminous efficiency than 30 if the lamp itself had to be forced in order to vaporize more sodium by the heat of the glow discharge; and thus the filament 11 though itself generally inferior in luminous efficiency to the lamp 10, nevertheless greatly increases the overall 35 efficiency of the whole device. Such a lamp may be operated at about 250° C. with a glow discharge energy consumption as low as about 0.1 watt per square centimeter of envelope surface. In addition, the filament 11 ballasts the lamp 10 40 very satisfactorily, as already explained.

The combination of the light of a filament 11 of tungsten with the yellow light from sodium vapor gives a combined light of improved quality. By using a lamp 10 with a charge of two or more 45 working substances,—as, for example, sodium and mercury, or sodium and cadmium, or sodium, mercury, and cadmium,—along with the tungsten filament 11, a combined light of still better quality can be produced. More complete mixture of the different kinds or color tones of light from lamp 10 and filament 11 can be obtained by enclosing the device in a light-diffusing globe, or by frosting the envelope 12, or by a combination of such 50 members. However, the filament 11 surrounding the lamp 10 mingles its light with that of the glow discharge very evenly in any case.

The device shown in Fig. 2 differs from that of Fig. 1 in that its filamentary heating "tube" around the lamp 10 consists of a multiplicity of 60 filament lengths all extending lengthwise of the lamp and arranged to surround it and cooperate with the internal heat of the lamp (from the electrodes 22, 22 and the glow discharge) heating its walls uniformly substantially throughout their extent. These filament lengths are shown 65 as one continuous (uncoiled) filament 11a strung in a zigzag on a double spider support resembling that of an incandescent lamp. Each spider consists of hook-ended wire supports 26a and a lead 70 support 26b, all fused into one of the buttons 27, 27 and having their ends bent down outside the lamp 10 substantially to the inner ends of its electrodes 22, 22. The lamp 10 with its leads 20, 21 in effect forms the rod or arbor of the double 75 spider. One end of the filament 11a is shown

welded to the lower spider lead support 26b, which is welded to the wire 29 electrically connected to the terminal lead 18, while the other end of the filament is welded to the upper spider lead support 26b. To connect the filament 11a 5 in series with the electrode gap of the lamp 10, the upper spider lead support 26b may be electrically connected to the upper lamp lead 21 by the lead wire 30a.

The device shown in Figs. 3 and 4 resembles 10 that of Fig. 1 rather than that of Fig. 2, having a continuous finely coiled filament 11 coiled or wound in a tubular spiral or helix surrounding the lamp 10. In this case, however, a light-permeable heat-diffuser 33, such as a glass shell 15 or tube, also surrounds the lamp 10, and may serve to carry its filament supports 25b, instead of the wire spider cage or frame of Fig. 1. As this tube 33 affords insulation, the supports 25b may consist of simple hook-ended wires. Being 20 heated by the filament 11, which is preferably outside of it rather than inside, the tube 33 not only reflects the lamp heat inward back on the lamp, but also diffuses the filament heat, so as to heat the lamp 10 uniformly (in conjunction 25 with the glow discharge and the electrode heaters 23, 23) with fewer large coils of the filament 11. While the tube 33 extends beyond the ends of the lamp 10, the filament 11 extends only to the inner ends of the electrodes 22, 22. Taken 30 together, the filament 11 and tube 33 act as a light-permeable electric heating tube around the lamp 10, and heat the latter very uniformly indeed.

For mounting the tube 33 with suitable inter- 35 spaces around it and inside it around the lamp 10, there are shown upper and lower spider ring devices 35, 35, which may be substantially alike. The lower device 35 comprises a sheet metal ring adapted to fit freely rather than tightly 40 around the tube 33, and having three or more spring finger strips 37 extending downward and then retroverted upward to embrace the lower edge of the tube wall, and then offset diagonally inward to bear against the lamp tube 10. The 45 ring 35 also has three or more spring finger strips 38 extending upward and then curled outward and downward (and inward) to bear against the inside of the outer tubular bulb 12. The lower spider ring device 35 may be supported by a 50 (diametral) cross member 39 welded at its middle to the central terminal lead 17. The upper device 35 does not require such support. The lower end of the filament 11 is welded to the upstanding wire extension 29b of the terminal lead 18; the 55 upper end of the filament is welded to an (inverted) L-bent wire 30b itself welded to the upper lamp lead 21b, and externally clearing the upper device 35. The upper lead 21b is shown with a pigtail or helical loop 21c therein, to obviate strains due to unequal thermal expansion and contraction. This feature might, of course, be 60 used in the constructions of Figs. 1 and 2.

In Figs. 2, 3, and 4, various parts and features are marked with the same reference characters as the corresponding ones in Fig. 1 (with an added 65 letter, where such distinction appears necessary), as a means of minimizing and avoiding repetitive description.

What I claim as new and desire to secure by Letters Patent in the United States is: 70

1. A lamp unit comprising an electric discharge vapor lamp device having a sealed container, electric heating means surrounding said lamp and being coextensive with the discharge path in said lamp so as to coat with the heat of the lamp 75

in heating the lamp walls uniformly substantially throughout the extent of said walls, and an evacuated envelope containing said lamp and heating means in the vacuum space thereof.

2. A lamp unit comprising an electric discharge vapor lamp device having a sealed container, electric heating means surrounding said lamp and being coextensive with the discharge path in said lamp so as to coact with the heat of the lamp in heating the lamp walls uniformly substantially throughout the extent of said walls, and connected in series with said lamp, and an evacuated envelope containing said lamp and heating means in the vacuum space thereof.

3. A lamp unit comprising an electric discharge vapor lamp device having a sealed container, incandescent filament means surrounding said lamp, and being coextensive with the discharge path in said lamp so as to coact with the heat of said lamp in heating the lamp walls uniformly substantially throughout the extent of said walls, the light emitted by said filament being mingled with that of the electric discharge, and an evacuated envelope containing said lamp and filament means in the vacuum space thereof.

4. A lamp unit comprising an electric discharge vapor lamp device having a sealed container, incandescent filament means surrounding said lamp, and being coextensive with the discharge path in said lamp so as to coact with the heat of the lamp in heating the lamp walls uniformly substantially throughout the extent of said walls, said filament being connected in series with said lamp to ballast said lamp, the light emitted by said filament being mingled with that of the electric discharge, and an evacuated envelope containing said lamp and filament means in the vacuum space thereof.

5. A lamp unit comprising an elongated electric discharge vapor lamp, electric heating resistance means extending lengthwise of the lamp substantially from end to end thereof, in a multiplicity of lengths surrounding said lamp so as to coact with the heat of said lamp in heating the lamp walls uniformly substantially throughout the extent of said walls, and an evacuated envelope containing said lamp and heating resistance means in the vacuum space thereof.

6. A lamp unit comprising an elongated electric discharge vapor lamp, an incandescent filament extending lengthwise of the lamp substantially from end to end thereof, in a multiplicity of lengths surrounding said lamp so as to coact with the heat of said lamp in heating the lamp walls uniformly substantially throughout the extent of said walls, the light emitted by said filament lengths being mingled with that of the electric discharge, and an evacuated envelope containing said lamp and said filament in the vacuum space thereof.

7. A lamp unit comprising an elongated electric discharge vapor lamp, electric heating resistance means extending around said lamp in a multiplicity of turns substantially from end to end thereof, so as to coact with the heat of said lamp in heating the lamp walls uniformly substantially throughout the extent of said walls, and an evacuated envelope containing said lamp and heating resistance means in the vacuum space thereof.

8. A lamp unit comprising an elongated electric discharge vapor lamp, an incandescent fila-

ment extending around said lamp in a multiplicity of turns substantially from end to end of the lamp, so as to coact with the heat of said lamp in heating the lamp walls uniformly substantially throughout the extent of said walls, the light emitted by said filament being mingled with that of the electric discharge, and an evacuated envelope containing said lamp and filament means in the vacuum space thereof.

9. A lamp unit comprising an electric discharge vapor lamp, tubular light-permeable electric heating means surrounding said lamp, and an evacuated envelope containing said lamp and heating means in the vacuum space thereof.

10. A lamp unit comprising an electric discharge vapor lamp, tubular light-permeable electric heating means surrounding said lamp and being connected in series therewith, and an evacuated envelope containing said lamp and heating means in the vacuum space thereof.

11. A lamp unit comprising an electric discharge vapor lamp, electric heating resistance means surrounding said lamp substantially throughout the extent of the lateral lamp walls, a light-permeable heat-diffusing shell also surrounding said lamp and heated by said heating resistance means, and an evacuated envelope containing said lamp, heating resistance means, and shell in the vacuum space thereof.

12. A lamp unit comprising an electric discharge vapor lamp, incandescent filament means surrounding said lamp so as to coact with the heat of said lamp in heating the lamp walls uniformly substantially throughout their extent, the light emitted by said filament being mingled with that of the electric discharge, a light-permeable heat-diffuser also surrounding said lamp, and an evacuated envelope containing said lamp, filament means, and heat diffuser in the vacuum space thereof.

13. A lamp unit comprising an electric discharge vapor lamp, electric heating resistance means surrounding said lamp substantially throughout the extent of the lateral lamp walls, a light-permeable heat diffusing shell also surrounding said lamp, said shell being mounted between said lamp and said heating resistance means, and an evacuated envelope containing said lamp, heating resistance means, and shell in the vacuum space thereof.

14. A lamp unit comprising an electric discharge vapor lamp, electric heating resistance means surrounding said lamp substantially throughout the extent of the lateral lamp walls, a light-permeable heat-diffusing shell also surrounding said lamp and supporting said heating resistance means, and an evacuated envelope containing said lamp, heating resistance means, and shell in the vacuum space thereof.

15. A lamp unit comprising an electric discharge vapor lamp, a light-permeable heat-diffusing shell surrounding said lamp substantially throughout the extent of the lateral lamp walls, electric heating resistance means extending around said shell in a multiplicity of turns substantially from end to end of the shell, and supported by the shell, and an evacuated envelope containing said lamp, shell, and heating resistance means in the vacuum space thereof.

GEORGE E. INMAN. 70