Oct. 17, 1961 J. G. MacHUTCHIN ET AL 3,005,102

SELF LUMINOUS LAMPS

Original Filed April 2, 1957

FIG. 1

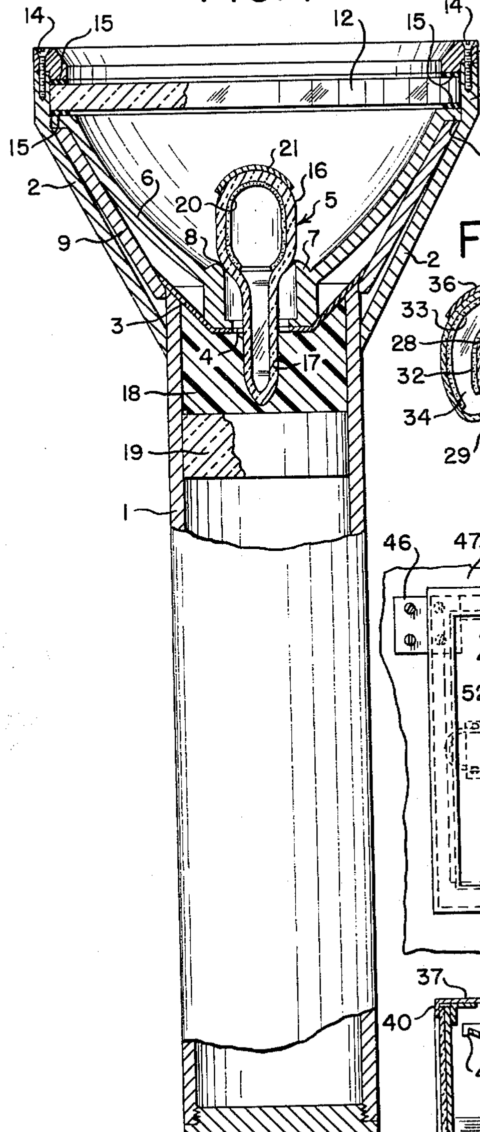


FIG. 2

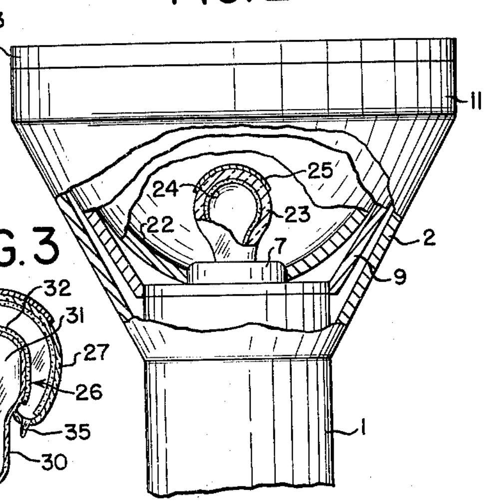


FIG. 3

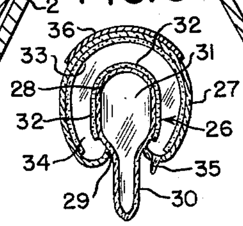


FIG. 4

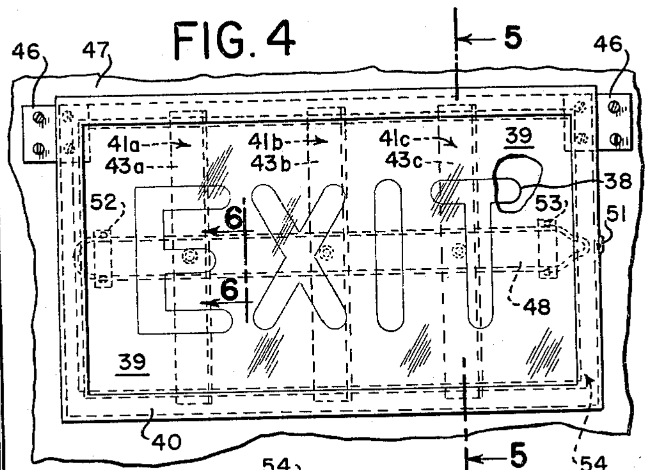


FIG. 5

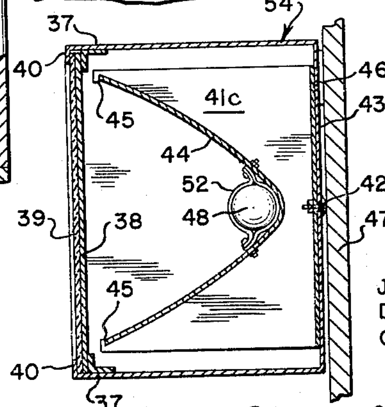
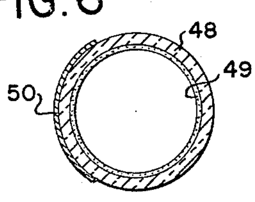


FIG. 6



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SELF LUMINOUS LAMPS

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Continuation of application Ser. No. 650,247, Apr. 2, 1957. This application Dec. 4, 1958, Ser. No. 778,202
5 Claims. (Cl. 250—77)

This invention relates to lamps of the self-luminous type in which the light source comprises a phosphor excited by radioactive material.

This application is a continuation of copending application Serial No. 650,247, filed April 2, 1957, now abandoned.

Heretofore it has been customary to employ self-luminous phosphors to produce visible light only of low intensity. These have been employed chiefly in luminescent paints and the like. They have not beeen useful in lamps to illuminate other objects because their light output is so low. Although there has been widespread use for such self-luminous phosphors, there has also been an unsatisfied demand for lamps capable of providing light of considerable intensity and in which the light source comprises a phosphor excited by a radioactive material. The present invention provides such a lamp and includes a novel light-giving element of inherent brightness heretofore unattainable. This element is mounted in a structure which includes a suitable light reflector, shielding members and other components which cooperate to provide many new characteristics and advantages.

An understanding of the invention will be had from the following description considered in connection with the accompanying drawing in which:

FIG. 1 illustrates the invention applied to a lamp of the portable or hand type shown partially in cross-section;

FIG. 2 shows a modification of the lamp of FIG. 1 which differs therefrom primarily in that the reflector is spherical instead of parabolic, and the shape of the light element is modified accordingly;

FIG. 3 illustrates a modified form of light element which has an increased and more efficient light output;

FIG. 4 is a front elevational view of a modification as embodied in a sign-type lamp structure;

FIG. 5 is a cross-sectional end view taken along the line 5—5 of FIG. 4; and

FIG. 6 is a cross-sectional view taken along the line 6—6 of FIG. 4, of the tubular light element.

The lamp structure illustrated in FIG. 1 comprises a cylindrical casing **1**, preferably a tube of metal such as brass, to which is attached a shell **2**, also of metal such as aluminum, for example. The casing is closed at the bottom, as shown. In the upper end of casing **1** a saddle cup **3** is secured by brazing. This cup may be of brass, if desired. A hole **4** at the center of the cup is large enough to receive the bottom of the self-luminous lamp or light element **5** described below. A polished reflector **6** of aluminum or chrome-plated brass is secured at its lower extremity to a supporting ring member **7** which rests in the cup **3** and, at its upper periphery, is shaped to support the lamp element. The two are preferably cemented together by an annular seal **8** of suitable material such as epoxy resin below described.

Between reflector **6** and shell **2** a layer of radiation-absorbing material **9** is interposed. This shield should be of material of a nature and thickness sufficient to absorb all or substantially all of the dangerous radiation emitted from the sides of the light element **5**. In the particular embodiment here illustrated this shield comprises a continuous sheet of lead approximately ⅛ inch thick. This shield is not required when relatively low radiation energies are involved, e.g., those of tritium.

The reflector **6** is bent outwardly at its upper edge to form a flange **10** which rests against the upper edge of the shoulder **9**, as shown. The periphery of flange **10** is of a diameter which makes a good fit within the straight rim portion **11** of shell **2**.

Across the top of reflector **6** a transparent cover **12** is placed so as to rest on flange **10**. This cover may be of a suitable plastic material such as methyl methacrylate, but preferably is of glass of sufficient density and thickness to absorb radiocative emanations from the front of the lamp. It may be flat as shown, or in the form of a lens. Occasionally it is desirable to employ a cover comprising a glass layer superimposed by a layer of plastic material. The usual commercial glass, especially lead glass, would be suitable for a short time, but experience has proved that thereafter such glass becomes darkened by the radioactive emanations. Therefore, it is important that a material be employed for this light-transmitting cover which will not darken appreciably under the conditions of use. A material especially successful for this purpose is cerium-bearing glass. In that type of glass cerium is usually present as a salt or an oxide, and commerical forms presently available include Corning #8362, Pittsburgh #6740 and Penberthy "Med-D." The density of the first-mentioned glass is approximately 3.2, of the second 2.7 and of the third 4.0.

The glass cover above described is held in place by a retaining ring **13**, here of aluminum, which is secured to the casing rim **11** by screws **14**. In order to make a tight seal between the reflector and the cover **12**, and also to avoid breakage of the glass, gaskets **15** are interposed above and below the cover **13** as shown. These gaskets should be of material which is not only resilient but which will maintain this and its other desired characteristics when subjected to radioactive emanations. A cork-like material known as Wisoid has been found to be suitable.

The light element **5** which incorporates several novel features, comprises a hollow capsule or bulb of transparent material. It has been found that glass of a cerium-bearing type, as above described in connection with cover **12**, is suitable for this purpose. It should be of material which does not darken appreciably under the conditions of use and which also can be maintained completely gas-tight under reasonable pressure. As shown, the element **5** comprises an upper bulbous portion **16** and a lower stem portion **17**. The lower portion passes through hole **4** in the saddle cup **3** and is retained in place by cementing material **18** which should be of a type substantially unaffected by radioactive emanations. Epoxy resin is suitable for this purpose. Two suitable epoxy resins are Araldite #502 manufactured by Ciba, and Epon #6 manufactured by Shell Chemical Corporation. Beneath the cement material **18** is a thick plug **19** of plastic material, such as methyl methacrylate. If additional shielding is required to the rear of the structure, this plug may be of lead, or a disc or cup-shaped piece of lead may be placed immediately above it.

The self-luminous light element **5** comprises the bulb **16, 17** as above described. In the particular embodiment here illustrated, the bulbous portion **16** was approximately ⅝ inch high and 7/16 inch maximum diameter, inside dimensions. The inner surface is coated with a layer of phosphor crystals of thickness corresponding to approximately 50 to 150 milligrams of phosphor per square cm. The art has developed a large variety of phosphors, certain of which provide a substantially colorless light, and others of which produce light of various colors. For many purposes the greenish light produced by zinc-cadmium-sulfide phosphor is satisfactory. This type is copper activated and includes only a small proportion of cadmium. Other well-known types of phosphors which are also suitable are zinc sulfide, zinc silicate, cadmium tungstate and cadmium sulfide.

The phosphor layer may be bound to the surface of the glass by various adhesives, including organic, inorganic and semi-organic types. Sodium silicate is an example of an inorganic adhesive suitable for the purpose. Organic adhesives include Du Pont butyl methacrylate, and certain colorless epoxy resins such as the mentioned Araldite #502. Inorganic types such as sodium or potassium silicate are preferred for their stable properties.

After the phosphor coating has been applied and properly dried, the bulb is evacuated and filled with radioactive gas, preferably krypton–85. This can conveniently be done through the stem **17** before it is sealed off. The quantity of gas injected into the bulb will determine the brightness to a large degree. Since krypton gas, as presently available from the U.S. Atomic Energy Commission, contains a comparatively small percentage (about 5%) of active Kr–85, a larger quantity of the gas must be used than would be the case were this proportion greater. In the light bulbs here discussed krypton gas pressures ranging from 150 to 400 millimeters of mercury are suitable. In a typical example this would represent approximately 150 millicuries of Kr–85. This combination is capable of producing brightness levels of from 500 to 1500 microlamberts. Provided higher surface radiation (radioactive) levels are tolerable, the brightness level can be increased substantially through use of bulbs designed for, and filled to, high internal gas pressures, i.e., in excess of one atmosphere. For reasons of safety it is desirable to maintain the pressure within the bulb less than that outside it, but this is not always possible especially for lamps which are to be employed at high altitudes or where brightness levels of several thousand microlamberts are required.

For many purposes a radioactive gas of energy lower than krypton–85 is suitable. For example, if it is sufficient that the light emitted from the lamp be of somewhat lower intensity, a radioactive gas such as tritium may be employed. Since tritium emits no gamma radiation and only low-energy beta, the shielding problems are less severe. An embodiment of the invention also suitable for tritium as the activating substance is described below in connection with FIGS. 4–6. Since tritium gas is presently available in purer form than is the krypton, it may sometimes be employed at a lower pressure than in the case of krypton, for example, 50 to 400 mm. of mercury. The trajectory range of beta particles emitted by tritium is of the order of 2.5 to 3.0 millimeters, so this fact should be considered in proportioning the cavity within the bulb which encloses the gas. In other words, if the inside radius of a given bulb is, say 5 mm., the gas in the central portion will have substantially no exciting effect on the phosphor material on the inner surface of the bulb, because it is too far away. This effect is less at lower internal gas pressures. In the case of krypton–85 the radiated particles, having more energy, are effective at a greater distance from their point of origin.

In the case of 99% pure tritium gas, several curies of tritium could be utilized while still maintaining the internal pressure at less than atmospheric. On this basis it is feasible to use up to approximately 30 times as many curies of tritium as Kr–85, within the same pressure range. Under these conditions brightness levels of from 300 to 1000 microlamberts can be readily achieved. Higher brightness levels are possible through use of tritium at pressures in excess of one atmosphere.

If the radiation-absorbing characteristic of the cover **12** is inadequate to shield sufficient of the the radioactive emanations, especially the more dangerous gamma

and high energy beta radiations, it is advisable to employ an additional screen such as cap **21** which is affixed to the top of the bulb. A sheet of lead is suitable for this purpose. It is preferable to include a light-reflecting surface or material (not shown) between this cap and the exterior surface of the bulb portion **16**. The dimensions and location of cap **21** are important in connection with the invention because they should be such as to intercept deleterious or dangerous radioactive emanations from the bulb, while intercepting to a minimum the light output from the lamp. For example, most of the radioactive emanations escaping from element **5** which are not intercepted by shield **9** will be intercepted by shield **21**. It is intended that the remaining few which escape will be absorbed by cover **12**. In the rearward direction cement **18** and plug **19** provide radiation shielding but, as above stated, additional lead shielding can be inserted here, if necessary. Although cap **21**, if opaque to light, will prevent direct light radiation forwardly from the light element, it does not appreciably interfere with the forward emission of light after reflection from parabolic reflector **6**. By proportioning light-emitting bulb **5** and reflector **6** in accordance with well known optical principles the light emitted from the lamp as illustrated can in fact be of quite uniform intensity over the area to be illuminated.

The self-luminous lamp illustrated in FIG. 2 is fundamentally the same as that of FIG. 1. Consequently many of the details shown in FIG. 1 are omitted from FIG. 2. The principal differences between the two embodiments are primarily of an optical nature. Reflector **22** is here represented as being of spherical curvature. Consequently, the cross-sectional area of the emitted light beam and the light-intensity distribution will be different as compared with the beam of FIG. 1. The use of a spherical reflector in the lamp of FIG. 2 necessitates for best efficiency a modification in the shape of the light-emitting bulb which in this case is more nearly spherical in form. This is apparent from the drawing in which the bulbous portion **23** and the phosphor coating **24** on the inside surface of the bulb are mostly spherical. As before, a lead shielding cap **25** is affixed to the upper portion of bulb **23**. It may be assumed that the nature of the radioactive gas enclosed within the bulb, the various materials and other structural details are, or may be, the same as those described in connection with FIG. 1.

FIG. 3 illustrates a modified form of a self-luminous element suitable for use in the lamp of FIG. 1 or of FIG. 2. For several reasons the form of light element here shown is preferable to the simpler form illustrated in the prior figures. Although the structure of the element of FIG. 3 may be slightly more expensive to manufacture, it is more efficient and will produce greater light intensity than the examples previously described. By forming the light element with a double wall, two notable improvements are introduced. First, the quantity of radioactive gas may be decreased because it is employed more efficiently, and this may reduce the cost for gas more than the structural cost is increased. Second, the total area of the luminescent phosphor surface is considerably increased and this increases the light output without materially increasing the overall size of the element. FIG. 3 is not drawn to scale with respect to the other figures, and the element may actually be no larger than the elements shown in the other figures.

As will be seen from FIG. 3, this light element comprises a core body **26** and an envelope **27** which completely surrounds the upper bulbous portion **28** of the core body. The two are sealed together near the bottom of the bulbous portion at which the neck **30** begins. If both the core body and the envelope are of glass as is presently preferred, they can readily be fused together to form an annular joint **29**. In this embodiment the inner cavity **31** of body **26** need not be evacuated, and may contain air. Before assembly a phosphor coating

32 is applied to the exterior surface of the bulbous portion 28. Also before assembly the inner surface of envelope 27 is coated with a phosphor layer 33. The gas may be introduced through a glass tube at point 35, after evacuation. This tube is then sealed off in the usual manner. The lead shielding cap 36 corresponds to caps 21 and 25 of the preceding figures and is employed for the same reason. The thickness of coating 32 can be greater than that of coating 33 because most of the light from the inner coating must pass through the outer coating. Under any given conditions there is usually an optimum coating thickness, which will fall within the following preferred ranges: For the inner coating 32 the thickness may correspond to approximately 150 or more milligrams of phosphor per square cm. of surface. For the outer coating 33 the thickness should correspond to approximately 50 to 150 milligrams of phosphor per square cm. of surface. Ideally, the coating layer 33 would be one phosphor crystal thick with no voids between crystals. The phosphor crystals of preferred type are of approximately 8 to 10 microns in thickness. However, the crystals employed are sufficiently translucent to absorb very little of the light which is intended to pass through them, if the layer is within the range specified.

The distance separating the inner surface of envelope 27 and the outer surface of body 28 parallel thereto should be as small as possible in view of certain factors: The cubical dimension of the resulting chamber 34 should be sufficient to accommodate the required quantity of radioactive gas with a given maximum permissible working pressure. As above indicated, the distance can be greater when a gas is employed which emits radioactive particles of higher energy and therefore of longer trajectory.

The embodiment of the invention illustrated in FIGS. 4, 5 and 6 is of the same fundamental type as that above described, but is adapted to a specifically different purpose. As before, it comprises a self-luminous light element secured approximately at the focus of an optical reflector, but in this instance it is of the box or sign type. It is important that the light be of uniform intensity over the illuminated area, but not necessarily of great brightness, if it is intended only to trans-illuminate a sign panel or the like. On the other hand, if the mentioned sign panel is replaced by a panel of clear glass, for example, and a light element of high intrinsic intensity is employed, the lamp will comprise a floodlight having a variety of advantages.

Accordingly, the lamp structure as illustrated in FIGS. 4 and 5 comprises a casing or box 54 which may be formed of any suitable sheet metal. In the example shown, the box was approximately 11½ inches long, 6 inches high and 5 inches deep. If shielding against radioactive emanations is required, this may readily be inserted within the box. At the front of the box, angles 37 are secured, as shown, so as to support a sign panel 38 which can be slipped in against them from the side. This would be the right side, or end, of the box as it appears in FIG. 4. This panel may be retained in place by bending over tab 51 which is integral with the frame 40. In the embodiment shown, the sign panel comprises a sheet of translucent glass which is covered with opaque paint except for the unpainted letters Exit through which the light passes. In front of the sign panel a cover glass 39 is inserted to protect the sign and retain it in place. This glass is preferably of the cerium-bearing type above described. Alternatively, it may comprise a thick sheet of suitable plastic material. This cover is retained in place by the metal frame 40.

Reflector 44 comprises the surface generated by translating a parabolic curve along a straight line. Therefore, any section taken through the reflector in a plane perpendicular to the mentioned line would show a parabola as represented in FIG. 5. Brackets 41*a*, 41*b* and 41*c* equally spaced along the back of box 54 support the reflector. These brackets, which fit the reflector contour, are secured to the back of the box by flanges 43*a*, 43*b* and 43*c*, respectively, and by bolts 42 passing through them. The reflector is locked in the brackets by means of claws 45 which are bent over the front edges of the reflector. The lamp as a unit may be attached to a wall or other support 47 by means of plates 46.

The light element shown in FIGS. 4, 5 and 6 comprises a straight tube 48 which, in the particular embodiment here illustrated, was approximately 10" long and ½" in diameter. Tubes of smaller diameter, for instance ¼", are preferable in some cases. The tube is preferably of non-darkening glass, such as that previously described, coated on the inside with a suitable phosphor layer 49 of the nature above specified, and sealed gas-tight at both ends after evacuating and filling with radioactive gas. A lead shield 50 extending the length of the tube 48 along the front thereof may be added, if desired, to increase the shielding of radioactive emanations. However, if tritium is employed as the exciting material this shield would be unnecessary, because the beta particles will not penetrate the glass wall of the self-luminous tube. Also, as above pointed out, the glass cover 39, as well as the sign panel 38 will provide shielding.

The tube 48 is retained in position in reflector 44 by means of clamps 52 and 53 secured at opposite ends, as illustrated. By suitably proportioning these clamps, the tubular light element may be positioned, as desired, with respect to the focal axis of the reflector. Thus the distribution of light from the reflector may be adjusted to provide light uniformly or non-uniformly distributed over the illuminated area. To provide uniform distribution, the light element should be symmetrically disposed with respect to the focal line.

The principles of construction, including the use of suitable materials as described in connection with the preceding figures, apply similarly to the embodiment of FIGS. 4, 5 and 6. For example, this light element could, as in FIG. 3, comprise a double-walled structure, such as would result from inserting a glass rod or closed glass tube in tube 48 and centrally locating it, leaving a cylindrical space between the resulting parallel walls which would comprise a gas chamber corresponding to chamber 34 of FIG. 3. From the description of that figure it will be evident that if the two opposing surfaces of this chamber are coated with phosphor layers and the chamber filled with krypton-85, as before, the light output of the element will be considerably increased. Useful brightness levels are also obtained in such an arrangement using tritium gas. Such a light element is especially adapted for use in the lamp structure of FIGS. 4 and 5 when employed as a flood lamp. In this case the sign panel 38 would be omitted.

The foregoing descriptions of specific embodiments of the invention are given merely by way of example, it being understood that no limitations are intended thereby.

We claim:

1. In a self-luminous light emitting unit, a casing, a light source in the casing, a reflector mounted within the casing and about the light source to direct from the casing the light emitted from said source, said light source comprising a sealed bulb of transparent material resistant to darkening under beta-ray bombardment, a phosphor coating on the inside surface of the said bulb, a radioactive beta-ray emitting gas within said bulb at subatmospheric pressure, all points in said bulb being within average beta-trajectory distance of the nearest portion of phosphor, and a beta-ray absorbing shield seated over the bulb substantially transverse to the path of light directed out of the casing, said shield being light-reflective on the surface thereof seated against said outer bulb.

2. A unit according to claim 1 which includes a window of transparent non-darkening material spanning said re-

flector and covering the light source therewithin, and a beta-ray absorbing shield surrounding said reflector within said casing.

3. In a self-luminous light emitting unit, a casing, a reflector mounted within the casing and having an optical center, a light source comprising a hollow gas-tight bulb of non-darkening glass including a bulbous portion and a relatively slender stem portion, means securing said stem portion in said casing so that said bulbous portion is substantially symmetrically positioned about the optical center of said reflector, a phosphor coating on the inner surface of said bulbous portion, a radioactive gas selected from the group krypton-85 and tritium within said bulbous portion, all points within said bulbous portion being within average beta-trajectory distance of the nearest portion of phosphor, a first cover of transparent non-darkening glass disposed across the top of said reflector within said casing, a second cover of transparent plastic disposed over said first cover, means securing both covers to said casing, gas-tight sealing means interposed between at least one of said covers and said casing, adjoining first shields of beta and gamma ray absorbing material between said reflector and said casing and in said casing behind said bulb, and a second shield of beta and gamma ray absorbing material seated on the front of said bulb to intercept radioactive radiations forwardly emitted from said bulb without substantially intercepting light reflected from said reflector, said second shield being light-reflective on the surface thereof seated against said bulb.

4. In a self-luminous light emitting unit, a casing, a light source in the casing, a reflector mounted within the casing and about the light source to direct light emitted from the source out of the casing, said light source being a self-luminous sealed bulb, a phosphor and a radioactive beta-ray emitting gas at sub-atmospheric pressure contained within said bulb, all points within said bulb being within average beta-trajectory distance of the nearest portion of phosphor, and a beta-ray absorbing shield seated on said bulb substantially transverse to the path of light directed out of the casing, said shield being light-reflective on the surface therof seated against said bulb.

5. In a self-luminous light emitting unit, a casing, a light source in the casing, a reflector mounted within the casing and about the light source to direct from said casing the light emitted from the source, said light source comprising a self-luminous sealed bulb, a phosphor coating on the inner surface of said bulb, a radioactive beta-ray emitting gas contained within said bulb at sub-atmospheric pressure, all points within said bulb being within average beta-trajectory distance of the nearest portion of phosphor, and a beta-ray absorbing shield seated on said bulb substantially transverse to the path of light directed out of the casing, said shield being light-reflective on the surface thereof seated against said bulb.

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