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 [73] Assignee **American Atomics Corporation**
Tucson, Ariz.
Continuation of application Ser. No.
552,109, May 23, 1966, now abandoned.

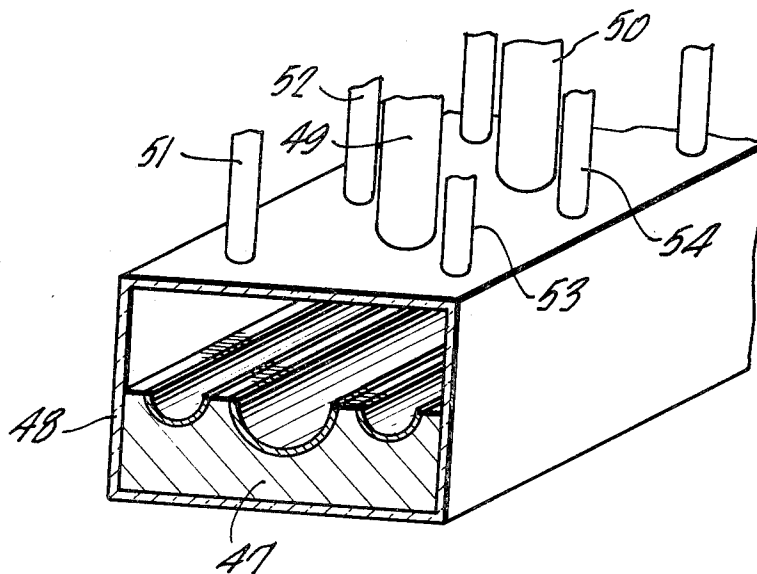
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Primary Examiner—Archie R. Borchelt
Attorney—Christie, Parker & Hale

[54] **EXTENDED SELF-LUMINOUS LIGHT SOURCES**
EMPLOYING FIBER OPTICS
15 Claims, 11 Drawing Figs.

[52] U.S. Cl. **250/77,**
250/71, 250/78, 250/106, 350/96
 [51] Int. Cl. **F21k 2/02**
 [50] Field of Search **250/71,**
71.5, 77, 84, 227; 340/380; 240/1 (EI); 40/130
(K); 88/1 (LCR)

ABSTRACT: A radiation-excited light source having a beta-emitting radioisotope within a sealed tube. Illumination is provided by the impingement of betas upon phosphor material within the tube. "Fiber optic" light transmission media are affixed longitudinally along the exterior of the tube and feed light to a plurality of display locations. In one embodiment a thin layer of phosphor is coated over the entire inner surface of the tube. In another embodiment a thicker layer of phosphor is coated to a metal shell positioned within the tube.



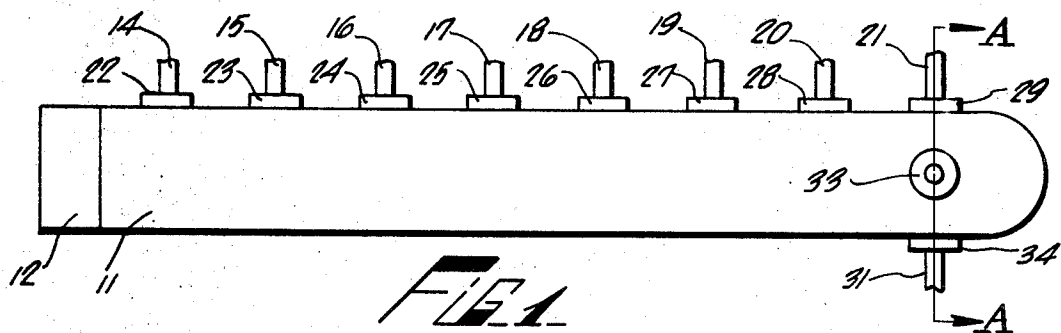


FIG 1

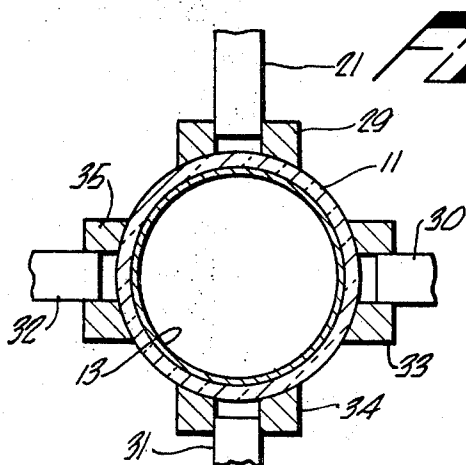


FIG 1A

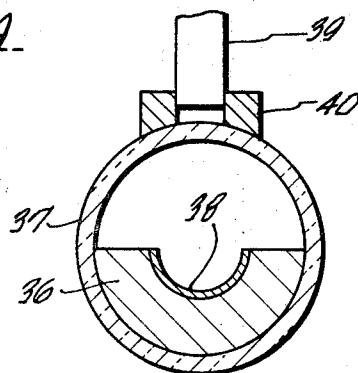


FIG 1B

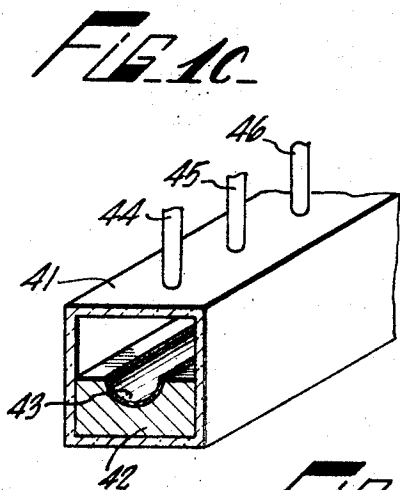


FIG 1C

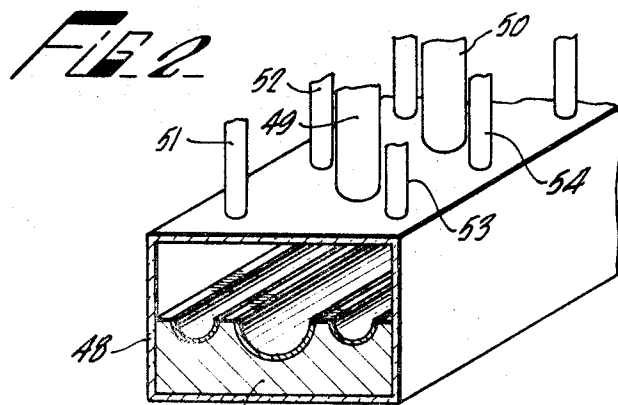


FIG 2

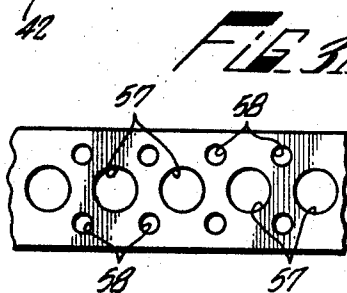


FIG 3A

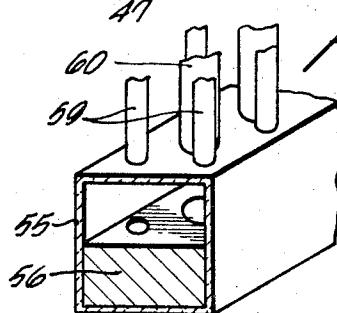


FIG 3B

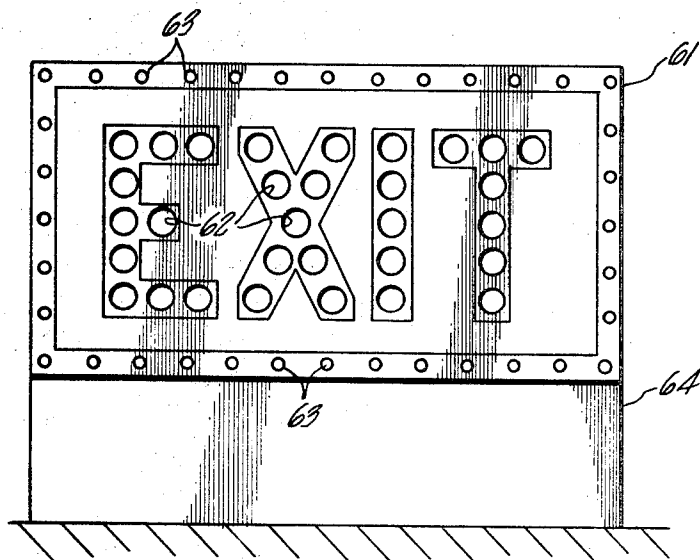


FIG 4A

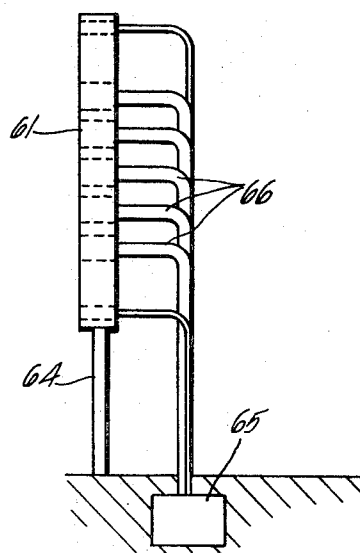


FIG 4B

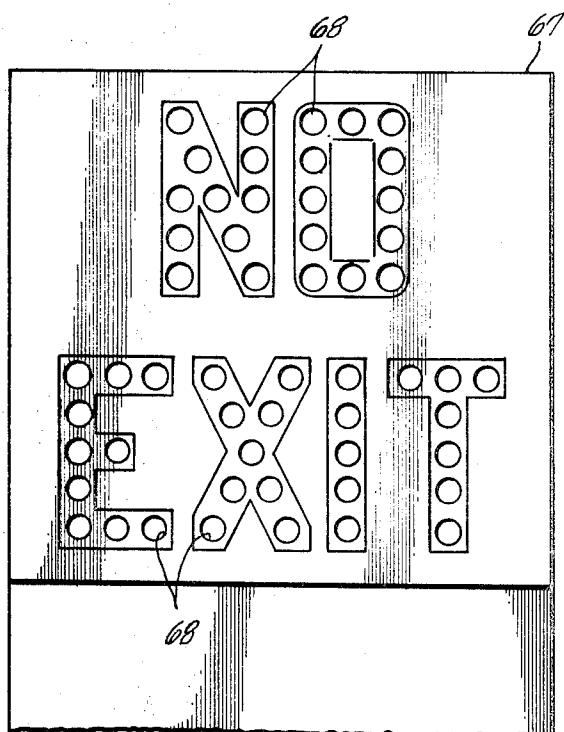
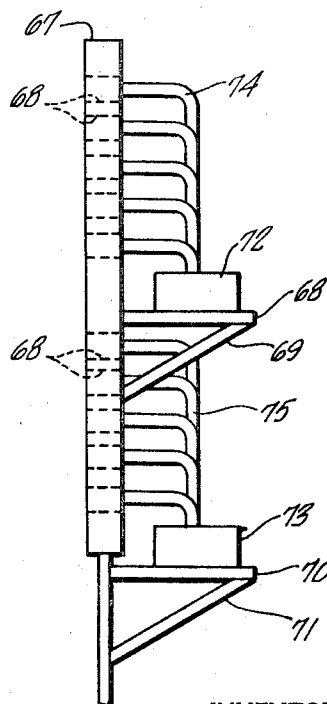


FIG 5A



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EXTENDED SELF-LUMINOUS LIGHT SOURCES EMPLOYING FIBER OPTICS

This is a continuation of a copending application, Ser. No. 552,109, filed May 23, 1966, and now abandoned.

This invention relates to radiation-excited self-luminous light sources and more particularly to such light sources in which light is generated along an extended area within the source and in which a plurality of "fiber optic" light transfer media may be linearly arranged along this area and utilized to transmit light to a plurality of display locations.

Prior art self-luminous sources have utilized phosphor coated surfaces within cavities containing a colorless beta-emitting radioisotope. An improved self-luminous source is described, for example, in the copending Pat. application of Theo. F. Linhart, Jr., Robert J. Doda and Arthur F. Mahon, Ser. No. 746,145, filed on July 19, 1968 and assigned to the assignee of the present application. A description of the use of light sources of this type in conjunction with "fiber optic" light transfer media may be found in the copending Pat. application of Harry J. Dooley, Robert J. Doda and Arthur F. Mahon, Ser. No. 805,042, filed on Mar. 6, 1969 and assigned to the assignee of the present application.

Prior art radiation-excited light sources have been small units of the "point source" variety. While a number of "fiber optic" transfer media may be utilized to transmit light from such a source to a plurality of display locations, the number of such locations which may be illuminated is highly limited.

An advantage of the present invention is that it provides an "extended source" radiation-excited light source which generates light over a substantially larger area than do prior art sources.

Another advantage of the present invention is that it enables a single radiation-excited light source to provide light for a plurality of linearly arranged "fiber optic" light transmission media.

An additional advantage of the present system is that it provides a single radiation-excited light source which generates light along a longitudinal portion of the source and in which the length of the light generating area may be designed to accommodate a particular number of "fiber optic" light transfer media.

Further advantages of the present system are that it provides an improved radiation-excited illumination system which is more flexible, more economical, more efficient and less hazardous than previous radiation-excited illumination systems.

In brief, the above and other advantages of the present invention are achieved by means of a radiation-excited light source in the form of a tube. The tube has phosphor material coated longitudinally along its interior and a radioisotope within the tube emits betas which impinge upon the phosphor thereby providing illumination. "Fiber optic" light transmission media may advantageously be affixed longitudinally along the exterior of the tube and utilized to feed light to a plurality of display locations. The tube may advantageously be 12 inches or more in length with its precise length governed by the number of "fiber optic" units desired to be coupled to the tube.

Although the tube is preferably straight for most applications it may also follow curved, zigzag, or other nonstraight paths. The tube itself is preferably made of cerium stabilized glass.

A thin layer of phosphor is advantageously coated over the entire inner surface of the glass tube if a low-energy gaseous radioisotope such as tritium is utilized. A thicker layer of phosphor is advantageously coated to a metal shell positioned within the tube when a high-energy gaseous radioisotope such as krypton 85, for example, is utilized. Alternatively, solid radioisotopes, such as promethium 147, may be included in a phosphor paint and applied to the interior of the tube in one continuous coat.

In embodiments of the present invention which utilize a metal shell to which phosphor is coated, the shell may have a single concave channel within which phosphor is coated. In al-

ternative embodiments which reduce the necessary amount of radioactive gas within the tube, the shell may have a plurality of smaller channels or a plurality of independent cavities. In embodiments in which various sized "fiber optic" cables are coupled to the tube, the shell may advantageously have a plurality of various sized phosphor-coated cavities opposite these cables.

A single self-luminous tube as described herein may be utilized, for example, to illuminate an entire sign. Any hazardous radiation profile exhibited by the tube may be eliminated by underground burial of the tube to a sufficient depth. Light is then fed from the buried tube to the sign by means of "fiber optic" light transmission media. Burial of the tube may also be advantageous when gaseous tritium is utilized as the radioisotope even though gaseous tritium presents no radiation hazard while sealed within the tube. Damage to the tube resulting in the escape of tritium into the atmosphere must be guarded against since tritiated water formed by such escaping tritium does present a hazard. Burial of the tube protects it from such damage.

For a complete understanding of the invention, reference should be made to the accompanying drawings, in which:

FIG. 1 depicts an improved radiation-excited self-luminous light source;

FIG. 1A depicts a cross section taken along the line A-A in FIG. 1;

FIGS. 1B and 1C depict alternative embodiments of the present invention;

FIGS. 2, 3A and 3B depict additional embodiments of the present invention; and

FIGS. 4A, 4B, 5A and 5B depict two signs illuminated by "extended-source" self-luminous light sources according to the present invention.

FIG. 1 depicts an improved radiation-excited self-luminous light source. A cross section taken along the line A-A in FIG. 1 is depicted in FIG. 1A. A cylindrical glass tube 11 is shown which is sealed at both ends. One end is sealed by metal tip 12, while the other end is shown sealed by glass. A thin phosphor layer 13 coats the interior surface of the tube 11. A beta emitting radioisotope of a concentration sufficient to excite phosphor layer 13 to luminescence is sealed within the tube 11. Light generated by the impingement of betas on the phosphor layer 13 is transmitted through the phosphor layer and through tube 11. "Fiber optic" light transmission media 14 through 21 are shown affixed to the top surface of tube 11 by means of metal fittings 22 through 29, respectively. The "fiber optic" light transmission media 14 through 21 may advantageously be of the type described in copending application, Ser. No. 805,042, filed on Mar. 6, 1969, referred to previously. The "fiber optic" light transmission media 14 through 21 are shown positioned longitudinally along the length of tube 11. Thus, an embodiment of the present invention, as shown in FIG. 1, enables a plurality of "fiber optic" light transmission media to be linearly arranged along the length of a single self-luminous light source. Additionally, the length of tube 11 may be designed to accommodate the particular number of "fiber optic" light transmission media needed for different applications. The length of tube 11 may advantageously be at least 12 inches in length.

In addition to being arranged linearly along the length of tube 11, the "fiber optic" light transmission media may additionally or alternatively be positioned around the circumference of tube 11. Thus, "fiber optic" light transmission media 30, 31 and 32 shown in FIGS. 1 and 1A may be positioned around the circumference of tube 11 and affixed thereby by means of fittings 33, 34 and 35, respectively.

The radioactive isotope within tube 11 may advantageously be a relatively low-energy radioisotope such as gaseous tritium, for example. With such a low-energy radioisotope the phosphor coating 13 may be of a thickness on the order of 0.002 to 0.003 inch. Alternatively, a solid radioisotope such as promethium 147, for example, could be mixed with phosphor material to form a paint which then could be applied to the inner surface of tube 11 in one continuous coating.

Should a relatively high-energy radioisotope such as krypton 85 be utilized, an embodiment such as that shown in FIG. 1B is advantageous. FIG. 1B depicts a cross section of an embodiment similar to that shown in FIGS. 1 and 1A. With respect to a high-energy radioisotope such as krypton 85, the energy absorption of a phosphor coating as thin as that shown in FIG. 1A is low and a thicker layer of phosphor is advantageous in order to take full advantage of the radioisotope. As the thickness of the phosphor layer increases, however, its transparency decreases. Thus, if the thicker phosphor layer were coated over the entire inner surface of the glass tube, only a relatively small amount of the light generated would pass entirely through the phosphor layer without being absorbed. In FIG. 1B, therefore, a metallic shell 36 is shown positioned within a glass tube 37. Shell 36 has a channel cut therein and a layer of phosphor 38 coats this channel. A radioisotope such as krypton 85 is sealed within tube 37 and impinges upon the phosphor coating 38, thereby exciting it to luminescence. A plurality of "fiber optic" light transmission media may be linearly arranged along the length of tube 37 and positioned opposite the channel in which phosphor layer 38 is coated. One such "fiber optic" media 39 affixed to tube 37 by fitting 40 is shown in FIG. 1B. Tube 37 is advantageously made of cerium stabilized glass which is not adversely affected by radiation.

When a radioisotope such as tritium or promethium 147 is utilized, no radiation hazard is presented. When other radioisotopes such as krypton 85, for example, are utilized, however, there may be a radiation hazard developed. As described in the compending application, Ser. No. 805,042, filed on Mar. 6, 1969, "fiber optic" light transfer media may be utilized to eliminate this radiation hazard by rendering shielding materials more effective and by transmitting light from a location where such hazard exists to a location where no hazard exists.

FIG. 1C depicts, in broken-away view, an embodiment of the present invention similar to that shown in FIG. 1B. In FIG. 1C a glass tube 41 having a rectangular cross section is shown to have a metal shell 42 positioned therein. Shell 42 has a longitudinal channel cut therein which has a layer of phosphor material 43 coated thereon. Sealed within tube 41 is a radioisotope such as krypton 85 which is of a concentration sufficient to excite phosphor layer 43 to luminescence. Arranged longitudinally along the length of tube 44 and affixed directly to tube 41 are "fiber optic" light transmission media 44, 45 and 46. Since tube 41 has a flat surface, the "fiber optic" media 44 through 46 may be affixed directly thereto rather than by means of fittings. The "fiber optic" media 44 through 46 are affixed to tube 41 in positions directly opposite the channel in shell 42 in which phosphor layer 43 is coated.

FIG. 2 depicts, also in broken-away view, an embodiment of the present invention similar to that shown in FIG. 1C. In FIG. 2, however, a metal shell 47 positioned within glass tube 48 has three channels therein; a large central channel and two smaller channels on opposite sides of the central channel and parallel to it. Each of these channels has a layer of phosphor material coated thereon. A radioactive isotope such as krypton 85, for example, is sealed within the tube 48 and excites the phosphor coating in the channels to luminescence. "Fiber optic" light transfer media 49 and 50 of a first diameter are affixed to the exterior of tube 48 opposite the central channel in shell 47. "Fiber optic" light transfer media 51 and 52 are affixed to the exterior of tube 48 opposite one of the smaller channels and "fiber optic" light transfer media 53 and 54 are affixed to the exterior of tube 48 opposite the other of the two smaller channels. Light transfer media 51 through 54 are of a smaller diameter than media 49 and 50 and may advantageously be used to transmit light to display locations which are of a smaller size than those to which light is transmitted by "fiber optic" media 49 and 50. The media 49 and 50 may, for example, be "fiber optic" cables of 1/2-inch diameter, while transfer media 51 through 54 may, for example, be "fiber optic" cables of 1/4-inch diameter. Such cables are presently available from E. I. DuPont De Nemours & Co. For

illustrative purposes, the space between shell 47 and the top of tube 48 is shown to be somewhat larger than it would ordinarily be. This space is made smaller than depicted in FIG. 2 in order to reduce the quantity of radioisotope which must be sealed within the tube in order to excite the phosphor coating to luminescence.

FIGS. 3A and 3B depict an embodiment of the present invention in which further savings in the quantity of radioisotope needed is achieved and in which a saving in the quantity of phosphor material needed may also be realized. FIG. 3B depicts, in broken-away view, a glass tube 55 within which metal shell 56 is positioned. FIG. 3A depicts a broken away top view of a portion of shell 56. Shell 56 has a plurality of individual cavities therein. A series of large cavities 57 are arranged linearly along the center of shell 56 and a plurality of smaller cavities 58 are arranged linearly along the two edges of shell 56. Each of the cavities 57 and 58 is coated with a layer of phosphor material. Again, the space between shell 57 and the top of tube 55 is shown to be exaggerated for purposes of illustration. A radioisotope also sealed within tube 55 excites the phosphor within each of the cavities 57 and 58 to luminescence. By providing individual cavities 57 and 58 rather than channels running along the entire length of shell 56, it is possible to reduce the amount of phosphor needed to coat the shell 56. Additionally, since the unfilled space within tube 55 is less when individual cavities rather than complete channels are formed within shell 56, a smaller quantity of radioisotope is needed in order to achieve the desired concentration of the radioisotope. "Fiber optic" light transfer media of a first diameter 59 are coupled to the exterior of tube 55 opposite each of the cavities 58. Similarly, "fiber optic" light transfer media 60 are coupled to the exterior of tube 55 opposite each of the cavities 57. As depicted in FIGS. 3A and 3B, the ends of the transfer media 59 and 60 are in registration with cavities 57 and 58, respectively. Again, for example, the smaller media 59 may be 1/4-inch diameter "fiber optic" cables, while the larger media 60 may be 1/2-inch "fiber optic" cables.

FIGS. 4A and 4B depict an illuminated sign utilizing "extended-source" self-luminous tubes as described herein. FIG. 4A depicts a sign 61 on which the word EXIT appears. The letters of this word are illuminated by light transmitted to display locations 62 within each letter. Additional display locations 63 are located along the outer edges of sign 61. The display locations 62 are of a larger size than the display locations 63 and may, for example, be one-half inch in diameter with locations 63 being one-fourth inch in diameter. FIG. 4B depicts a schematic side view of the sign shown in FIG. 4A. Sign 61 is shown supported above ground level by support means 64. A tubular light source 65 such as that described herein is shown in FIG. 4B to be buried beneath the surface of the earth. "Fiber optic" cables 66 transmit light generated by the buried source 65 to the light display locations 62 and 63 on sign 61. The entire sign 61 is thus illuminated as a result of light generated by a single light source. The illumination of sign 61 is achieved more economically and more efficiently as a result of being illuminated by a single source. If source 65 utilizes a radioisotope which presents a radiation hazard, the burial of the source may be utilized to eliminate this hazard. The earth surrounding source 65 then, effectively, provides a radiation shield. Alternatively, the source 65 may be enclosed in a lead housing or other radiation shield material; it may also be both enclosed in a housing and buried. The ability of the "fiber optic" light transfer media to permit transfer of light from the source to display locations, while at the same time permitting the radiation shield material to completely surround the radioisotope as described in the compending Pat. application, Ser. No. 805,042, referred to previously, may also be utilized to achieve shielding in an embodiment similar to that shown in FIGS. 4A and 4B.

Besides eliminating any radiation hazard presented by the radiation profile of source 65, burial of source 65 also serves to protect it against any damage whereby a gaseous

radioisotope may be allowed to escape from the sealed tube. Thus, for example, although gaseous tritium does not present a hazardous radiation profile when within the sealed tube, it does present a danger if allowed to escape into the atmosphere. Tritium escaping into the atmosphere forms tritiated water which can provide a hazard to human beings. Burial guards against such escape into the atmosphere.

FIGS. 5A and 5B depict an alternative embodiment of an illuminated sign. FIG. 5A depicts sign 67 on which the two words NO EXIT appear with one word being positioned vertically above the other. Each letter of the two words is illuminated by means of light transmitted to a plurality of light display locations 68. FIG. 5B depicts a broken-away side view of sign 67. As shown in FIG. 5B, a support member 68 is affixed to the rear of sign 67 by support strut 69 and a support member 70 is affixed to the rear of sign 67 by support strut 71. Self-luminous extended-sources 72 and 73, of the type described herein, are positioned on support members 68 and 70, respectively. "Fiber optic" light transfer cables 74 transmit light from source 72 to the display locations of the upper word appearing on sign 67 and "fiber optic" light transfer cables 75 transmit light generated by source 73 to the display locations of the lower word appearing on sign 67. In the embodiment shown in FIGS. 5A and 5B, a separate extended-source self-luminous tube is utilized for the illumination of each horizontal row of characters appearing on a sign. By using a separate light source for each row of characters, the light source illuminating a particular row may be affixed to the rear of the sign in close proximity to the row of characters it illuminates. Consequently, fairly short "fiber optic" cables may be utilized to transmit light from the source to the row being illuminated by that source. Since lengthy "fiber optic" cables are not needed, a high efficiency of light transfer from the source to the illuminated characters is achieved.

The embodiments which have been described are considered to be illustrative of the present invention. Accordingly, it is to be understood that various and numerous other arrangements may be devised by one skilled in the art without departing from the spirit and scope of this invention.

We claim:

1. A self-luminous light source comprising:
 - a translucent, elongated cylindrical tube sealed at both ends, the tube being disposed on a longitudinal axis;
 - a layer of phosphor material coated over substantially all of the interior surface of the tube;
 - a beta-emitting radioisotope within the tube, the quantity of the radioisotope being sufficient to excite the phosphor to luminescence; and
 - a plurality of "fiber optic" light transmission media for transmitting light by substantially total internal reflection, one end of the media being connected to the tube and positioned along the tube in a row parallel to the longitudinal axis.
2. A self-luminous light source according to claim 1 further comprising a plurality of "fiber optic" light transmission media connected to the tube and positioned circumferentially around the tube.
3. A self-luminous light source according to claim 1 in which the radioisotope is gaseous tritium.
4. A self-luminous light source comprising:
 - an elongated light transmissive tube sealed at both ends, the tube being disposed on a longitudinal axis;
 - a shell positioned within the tube and having at least one elongated channel parallel to the longitudinal axis;
 - a layer of phosphor material formed on the surface of the channel;
 - a radioactive particle emitting material within the tube, the quantity of the radioactive material being sufficient to excite the phosphor to luminescence; and
 - a plurality of "fiber optic" light transmission media for transmitting light by substantially total internal reflection, one end of the media being coupled to the tube and positioned opposite the channel in a row parallel to the longitudinal axis.

5. A self-luminous light source according to claim 4 in which the radioisotope is gaseous krypton 85.

6. A self-luminous light source according to claim 5 in which the tube is made of cerium stabilized glass.

7. A self-luminous light source according to claim 4 in which the shell has a first channel of a first width and a second channel of a second width therein, each channel being disposed parallel to the longitudinal axis and having a layer of phosphor material formed in it; in which one end of a first plurality of "fiber optic" light transmission media of a first diameter are coupled to the tube and arranged along the tube opposite the first channel in a row parallel to the longitudinal axis; and in which one end of a second plurality of "fiber optic" light transmission media of a second diameter are coupled to the tube and arranged along the tube opposite the second channel in a row parallel to the longitudinal axis.

8. An illuminated sign comprising:

a display member having a first plurality of display locations thereon, the display locations being arranged in a common plane to form at least one informational character; an elongated light transmissive tube sealed at both ends, the tube being disposed on a longitudinal axis parallel to the common plane;

a layer of phosphor material formed within the tube;

a radioactive particle emitting material within the tube, the quantity of the radioactive material being sufficient to excite the phosphor to luminescence; and

a first plurality of "fiber optic" light transmission means for transmitting light by substantially total internal reflection, one end of the first plurality of light transmission means being connected to the tube and positioned along the tube in a row parallel to the longitudinal axis, the other end of the first plurality of light transmission means being coupled to different ones of the first plurality of display locations for transmitting light from the tube to respective ones of the first plurality of display locations.

9. An illuminated sign according to claim 8 in which the tube is buried beneath the surface of the earth.

10. An illuminated sign according to claim 8 in which the display member has a second plurality of display locations thereon, each of the first plurality of display locations being of a particular first size and each of the second plurality of display locations being of a particular second size, and further comprising:

a second plurality of "fiber optic" light transmission means for transmitting light by substantially total internal reflection, one end of the second plurality of light transmission means being connected to the tube, the other end of the second plurality of light transmission means being connected to different ones of the second plurality of display locations for transmitting light from the tube to respective ones of the second plurality of display locations, each of the first plurality of "fiber optic" means being of a particular first size and each of the second plurality of "fiber optic" means being of a particular second size.

11. An illuminated sign according to claim 10 in which the display locations of the second plurality of locations are positioned near the periphery of the display member.

12. An illuminated sign comprising:

a display member having a first plurality of display locations positioned on the face thereof and arranged to form at least one informational character;

the display member having a second plurality of display locations positioned on the face thereof and arranged to form at least one informational character;

the second plurality of display locations positioned above the first plurality of display locations;

first and second support members affixed to the rear of the display member, the second support member being positioned above the first support member;

first and second translucent tubes positioned on the first and second support members, respectively;

each tube being sealed at both ends and having a layer of phosphor material and a beta emitting radioisotope

within the tube, the quantity of the radioisotope being sufficient to excite the phosphor to luminescence;
a first plurality of "fiber optic" light transmission media for transmitting light by substantially total internal reflection, one end of the light transmission media being connected to the first tube and positioned in a row longitudinally along the tube, the other end of the light transmission media being connected to respective ones of the first plurality of display locations for transmitting light from the first tube to the first plurality of display locations; and
a second plurality of "fiber optic" light transmission media for transmitting light by substantially total internal reflection, one end of the light transmission media being connected to the second tube and positioned in a row longitudinally along the tube, the other end of the light transmission media being connected to respective ones of the second plurality of display locations for transmitting light from the second tube to the second plurality of display locations.

13. A self-luminous light source comprising:
an elongated, light transmissive enclosure disposed on a longitudinal axis;
a material forming a phosphor surface within the enclosure;
a radioactive particle emitting material within the enclosure, the quantity of the radioactive particle emitting material being sufficient to excite the phosphor surface to

luminescence; and
a plurality of elongated, light transmissive tubes, one end of the tubes being arranged on the exterior of the enclosure in a row along the longitudinal axis so light emanating from the enclosure is coupled to the tubes.

14. The light source of claim 13, in which the other end of the tubes is arranged in a plane substantially removed from and parallel to the longitudinal axis.

15. A self-luminous light source comprising:
an elongated, light transmissive, sealed enclosure, the enclosure being disposed along a longitudinal axis;
a shell positioned within the enclosure and having a plurality of individual cavities arranged in a row parallel to the longitudinal axis;
a layer of phosphor material formed on the surfaces of the cavities;
a radioactive particle emitting material within the enclosure, the quantity of the radioactive material being sufficient to excite the phosphor to luminescence; and
a plurality of "fiber optic" light transmission media for transmitting light by substantially total internal reflection, one end of the media being coupled to the enclosure and positioned opposite the cavities in a row parallel to the longitudinal axis and in registration with the respective cavities.

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