April 24, 1962 J. SILVERMAN 3,031,519

ENERGY SOURCE DEVICE

Filed Aug. 7, 1956

Fig. 1.

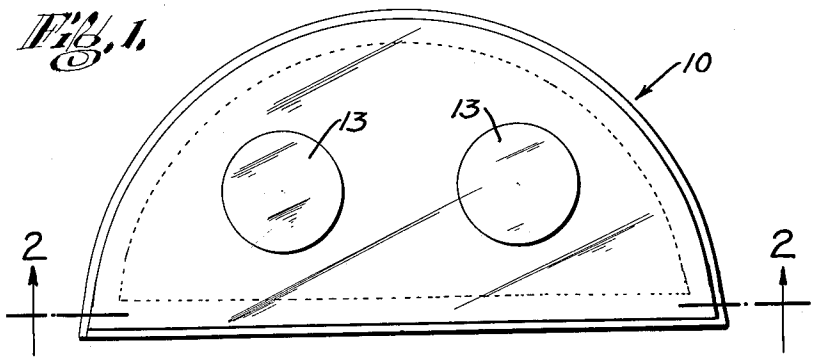
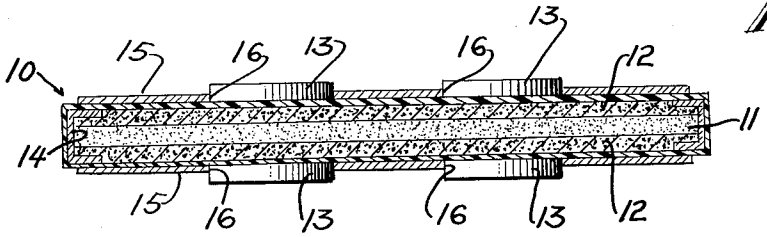


Fig. 2.



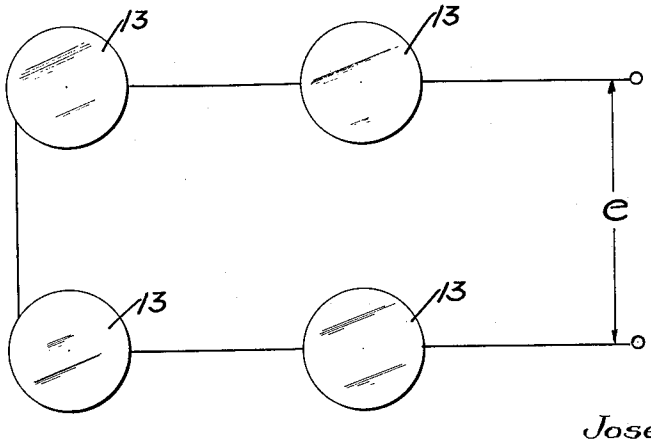


Fig. 3.

INVENTOR
Joseph Silverman
BY
Ernest A. Jensen
ATTORNEY

United States Patent Office 3,031,519 Patented Apr. 24, 1962

3,031,519

ENERGY SOURCE DEVICE

Joseph Silverman, Hicksville, N.Y., assignor to Associated Nucleonics, Inc., a corporation of New York

Filed Aug. 7, 1956, Ser. No. 602,578
15 Claims. (Cl. 136—89)

The present invention relates to nuclear energy, and, more particularly, to a unitary device for supplying such energy and converting the same to light and electrical energy.

Accordingly, an object of the present invention is to provide such a device, with or without cell means in assembly therewith, which is small in size, compact in arrangement, light in weight and economical to manufacture.

Another object is to provide such a device which is capable of producing an electrical output on an order to perform useful work.

A further object is to provide such a device which has a long useful life.

Other and further objects of the invention will be obvious upon an understanding of the illustrative embodiment about to be described, or will be indicated in the appended claims, and various advantages not referred to herein will occur to one skilled in the art upon employment of the invention in practice.

In accordance with the present invention, the foregoing objects are accomplished by providing an energy source device for converting the disintegrating energy of a radioactive or nuclear source to light and then electrical energy which comprises a sealed receptacle, a source of principally beta radiation emissive particles essentially free from gamma radiation and a phosphor confined and arranged in the receptacle so that light emitted by the phosphor in response to disintegration of the source can be directed on photovoltaic cell means adapted to convert the light to electrical energy.

A preferred embodiment of the invention has been chosen for purposes of illustration and description, and is shown in the accompanying drawing, forming a part of the specification, wherein:

FIG. 1 is a plan view of a device in accordance with the invention including a source device and photovoltaic cell means.

FIG. 2 is a sectional view taken along the line 2—2 on FIG. 1.

FIG. 3 is a schematic wiring diagram illustrating the connection of the cell means in an electrical energy supply circuit.

Referring to the drawing in detail a device is shown, FIGS. 1 and 2, which essentially comprises a receptacle **10**, a radioactive source **11** and a phosphor **12** confined in the receptacle. Photovoltaic cell means **13** adjacent the phosphor are adapted to be energized by the light emitted by the phosphor in response to disintegration of the source to produce an electrical output.

The source and phosphor may comprise an admixture of radioactive source and phosphor powders, a source in solution or colloidal suspension in a liquid phosphor, or a layer containing or consisting of a radioactive source adjacent one or more layers of a phosphor.

The receptacle **10** is illustrated as being shallow or disc-like. The peripheral geometrical configuration of the receptacle may be varied to suit the purpose for which the device is employed and is shown herein as being semi-circular for insertion into a circular case containing a mechanism to be powered by the battery.

The receptacle **10** may be formed of transparent materials such as polystyrene or polymerized methyl methacrylate through which light radiations ranging from the visible to the ultra-violet in the spectrum are adapted to be transmitted. A strip **14** of aluminum foil or its equivalent is applied to the peripheral wall portion of the receptacle, for example, at the interior of the receptacle, and a sheet **15** of aluminum foil or its equivalent is applied to each of the end wall portions of the receptacle. The sheets **15** have one or more openings **16** therein, two being shown in each sheet by way of example, which provide windows, and a photovoltaic cell **13** is positioned in each of the openings. The aluminum foil or its equivalent serves as a light reflecting means adapted to direct the light emitted by the phosphor through the windows and onto the light sensitive means of the cells to more efficiently utilize the emitted light for conversion to electrical energy. The aluminum foil strip **14** is impervious to beta particles, whereby radiation damage to the peripheral wall portion of the receptacle is prevented.

The foregoing arrangement renders the receptacle opaque and confines the emitted light therein except as the light passes into the cells **13**. Alternatively, the cells **13** and the sheets **15** could be positioned within the receptacle adjacent the end walls, or the cells could be so positioned and sheets **15** with or without openings **16** could be applied to the exterior of the end walls to render the receptacle opaque. Also, it will be appreciated that the receptacle and cells may be of such dimensions whereby a cell at each side would constitute the end wall and would render the receptacle opaque thereat without resorting to sheets **15**. Still another arrangement which is contemplated comprises molding the cells into the end wall structure to unitize the receptacle and cell assembly. In certain cases for example where the reflectors **15** are at the interior or are omitted, the receptacle may be formed of material which renders it opaque. In all cases, it is desirable that the receptacle is sealed securely to confine the source and phosphor therein.

As previously indicated, the radioactive source and phosphor may be in layer or sandwich arrangement. In the preferred form of the device a layer of source material **11** is sandwiched between a pair of layers of phosphor material **12**. The layers of phosphor material are impervious to beta ray penetration, whereby radiation damage to the portions of the receptacle adjacent such layers is prevented.

However, in a simplified but less efficient device having a window or windows at only one side wall portion, it is conceivable that a layer of source material could be placed adjacent a dense or opaque windowless wall portion and a layer of phosphor material could be placed between the source layer and the windowed wall.

In the foregoing preferred arrangement, the source layer **11** may be a powder, a metal foil or a powder dispersed in a foil, and the phosphor layer **12** may be a single crystal, a packed powder or a liquid.

In a practical embodiment of the device illustrated herein, the receptacle is formed of optical grade polystyrene having a thickness of about .007 inch. The receptacle has a thickness of about .0515 inch, and is semi-circular in-form, with the straight peripheral edge portion having a length of about .675 inch, whereby the volumetric capacity of the receptacle is about .0067 cubic inch. The layer **11** has a thickness of about .0115 inch, and the layers **12** have a thickness of about .013 inch. The aluminum strip **14** has a thickness of about .008 inch, the reflector sheets **15** have a thickness of about .005 inch, and the cells **13** have a thickness of about .010 inch, whereby the overall thickness of the device does not exceed about .0715 inch.

The thickness of the phosphor layers **12** is sufficient to stop beta particles emitted by the radioactive source, whereby all significant radiation is confined to the sandwich or is stopped by the aluminum foil strip **14**, whereby a highly efficient conversion of beta rays to light is attained.

A suitable source of radioactive material is $Pm_2^{147}O_3$, and a suitable phosphor is hexagonal zinc sulphide (ZnS) preferably activated with .01% copper powder. A more efficient light emitting unit can be provided by these materials by employing a source layer **11** comprising an admixture of 48 mg. of the activated zinc sulphide and 5.7 mg. of the carrier-free $Pm_2^{147}O_3$, and a phosphor layer **12** consisting of 54 mg. of the activated zinc sulphide.

This intermediate source layer **11** is relatively thin (.0115 inch) and the source particles are well scattered therein because of the 5.7 to 48 ratio of $Pm_2^{147}O_3$ to zinc sulphide. Since hexagonal zinc sulphide has a relatively low light absorbing coefficient, the layers **12** and the layer **11** are sufficiently translucent to enable light reflected by the sheet **15** at one end wall to be directed through these layers and impinge on the cell means **13** or the sheet **15** at the other end wall. If such reflected light is of a high value, it is conceivable that it may be again reflected in the opposite direction through the layers to impinge on the cell means at the end walls where reflection first took place, ad infinitum.

The use of a mixture of source and phosphor powders in the layer **11** also reduces self-absorption of the radioactive emissions to a minimum. Thus, absorption taking place results in a more efficient production of light.

The source is equivalent to 4.5 curies of Pm^{147} which has a 2.7 years one-half life and has a beta power output of 2200 microwatts, falling off to 1000 microwatts at the end of three years. This source is a pure beta emitter with a maximum beta energy of .22 m.e.v. The beta to light conversion causes about 550 microwatts to be emitted by the phosphor mixture when made up and about 250 microwatts at the end of three years, with the luminous light output decreasing from .24 to .11 lumens in the three year period. This light output is converted by the cells to about 27 microwatts at the beginning and about 13 microwatts at the end of the period. These cells are capable of providing a voltage of about .25 per cell at the end of three years. For example, silicon and cadmium sulphide type cells are suitable for this purpose.

Preferably, where two or more cells **13** are utilized, these cells are connected in a series circuit, as shown in FIG. 3, whereby the sum *e* of the cell voltages is of a value to operate an electromagnetic device (not shown).

The photocell-source assembly described herein may further be encased in tantalum or its equivalent having a thickness of about .077 inch, whereby the completed unit does not constitute a health hazard.

As previously indicated herein the source could be in a liquid phosphor, for example, $Pm^{147}Cl_3$ in a solution of para-terphenyl in dioxane.

From the foregoing description, it will be seen that the present invention provides an energy source device or battery which is simple and practical and sufficiently efficient to produce electrical energy for a useful purpose. The specific ilustrative embodiment herein has the advantageous characteristics of negligible radiation damage to the container and the photocells, the source and phosphor arrangement results in almost all of the radioactive emissions being absorbed in the phosphor, and light is radiated and/or reflected from the phosphor to the photocells in an efficient manner.

The energy which is not converted to electricity appears as heat, but the calorific value thereof is so low that no sensible heating can occur which might cause thermal disintegration of the device.

As various changes may be made in the form, construction and arrangement of the parts herein, without departing from the spirit and scope of the invention and without sacrificing any of its advantages, it is to be understood that all matter herein is to be interpreted as illustrative and not in any limiting sense.

I claim:

1. A unitary source device for converting the disintegration energy of a radioactive source to electricity comprising a sealed receptacle having closely spaced opposite walls joined by a side wall defining a space therein, at least one of said opposite walls having a portion capable of transmitting light outwardly from said space, a phosphor and a radioactive beta particle source free of nonlight generating beta ray energy absorbent material confined and arranged in said space substantially to fill the same so that light emitted by said phosphor in response to disintegration of said source is directed outwardly through said one opposite wall with absorption of beta particles from said source by said phosphor, and a photovoltaic cell overlying said light transmitting wall portion and having photosensitive means disposed to respond to light transmitted through said wall portion from inside the receptacle.

2. A device according to claim 1, wherein said source and said phosphor are present in the form of powder.

3. A device according to claim 1, wherein at least portions of said source and said phosphor are present in intimate admixture.

4. A device according to claim 1, wherein said source is admixed in a liquid phosphor.

5. A device according to claim 1, wherein said receptacle has light reflective means on a wall thereof facing the interior of said receptacle.

6. A device according to claim 1, wherein said light reflecting means has beta ray shielding properties.

7. A unitary energy source device for converting the disintegration energy of a radioactive source to electricity comprising a sealed receptacle having a space therein and a wall formed with a plurality of portions through which light can be transmitted outwardly from said space, a radioactive source of beta particles and a phosphor confined and arranged in said space to substantially fill the same so that light emitted by said phosphor in response to disintegration of said source is directed outwardly through said portions, said source and said phosphor being present in an amount to produce sufficient light for causing photovoltaic cell means to produce an electrical output on an order to perform useful work, and a photovoltaic cell overlying and closing each of said light transmitting portions and having means presenting a light sensitive material at said portions to thereby be energized by said transmitted light, said cells being connected in circuit for utilizing the combined output thereof.

8. A unitary energy source device for converting the disintegration energy of a radioactive source to electricity comprising a sealed receptacle having a space therein and a wall formed with a portion through which light can be transmitted outwardly from said space and provided at other portions with light reflecting means facing the interior of said receptacle, a radioactive source of beta particles and a phosphor combined and arranged in said space to substantially fill the same, so that light emitted by said phosphor in response to disintegration of said source is directed outwardly through said portion, said source and said phosphor being present in an amount to produce sufficient light for causing photovoltaic cell means to produce an electrical output on an order to perform useful work, and a photovoltaic cell secured to said receptacle and having means presenting a light sensitive material overlying said portion to thereby be energized by said transmitted light.

9. A unitary energy source for converting the disintegration energy of a radioactive source to light comprising a disc-like sealed receptacle having closely spaced opposite walls joined by a side wall defining a space therein, said opposite walls having light transmitting windows formed therein, a radioactive beta particle source layer free of nonlight generating beta ray energy absorbent material in said receptacle, layers of light generating beta particle responsive phosphor disposed between said radio-

active source layer and each of said opposite walls, respectively, said layers substantially filling said space and said phosphor layers being substantially impervious to beta particles emitted by said source layer.

10. A device according to claim 9, wherein said intermediate layer comprises an admixture of beta particle source material and a phosphor.

11. A device according to claim 10, wherein said intermediate layer contains an activator for said phosphor.

12. A device according to claim 9, wherein said receptacle wall portions are formed of transparent material and have light reflecting means thereon facing the interior of said receptacle formed with openings to provide said windows.

13. A device according to claim 12, wherein said light reflecting means are formed of a material having beta ray shielding properties.

14. A device according to claim 12, wherein said light reflecting means are formed with a plurality of openings at each side of said receptacle wall portions to provide said windows.

15. A unitary energy source device for converting the disintegration energy of a radioactive source to electricity comprising a disc-like sealed receptacle having a space therein and wall portions formed of transparent material at opposite sides thereof; light reflecting means on said wall portions facing the interior of said receptacle and having a plurality of openings to provide windows through which light can be transmitted outwardly from said space,

a layer of a phosphor in said receptacle adjacent each inner side thereof having a window formed therein, an intermediate layer of a radioactive source of beta particles sandwiched between said phosphor layers, said layers being arranged to substantially fill said space, and a photovoltaic cell positioned adjacent each of said windows, said cells being in electrical connection for utilizing the combined output thereof.

References Cited in the file of this patent

UNITED STATES PATENTS

2,582,981	Fua	Jan. 22, 1952
2,681,416	Thompson	June 15, 1954
2,754,428	Franks et al.	July 10, 1956
2,769,916	Tittle	Nov. 6, 1956
2,871,555	Foster	Feb. 3, 1959

FOREIGN PATENTS

638,106	Great Britain	May 31, 1950
1,076,816	France	Apr. 21, 1954

OTHER REFERENCES

Thomas: "Nuclear Batteries Types and Possible Uses," in Nucleonics, vol. 13, No. 11, November 1955, pp. 129–133; pp. 130–131 relied upon.

Wallhausen: "Uses of Radioisotopes in the Production of Self-Luminous Compounds," in Nations, vol. 15, Aug. 8–20, 1955, pages 307–309; page 309 relied upon.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,031,519 April 24, 1962

Joseph Silverman

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 29, for the claim reference numeral "1" read -- 5 --.

Signed and sealed this 11th day of September 1962.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents