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[54] **WINDOW FOR RADIATION DETECTORS AND THE LIKE**

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[52] **U.S. Cl.** **250/389**; 250/370; 250/510; 313/93

[51] **Int. Cl.**[2] **H01J 39/26**

[58] **Field of Search** 250/389, 526, 510, 505, 250/370; 313/93

[56] **References Cited**

UNITED STATES PATENTS

2,461,254	2/1949	Bassett	250/510
2,552,723	5/1951	Koury	313/93
2,574,000	11/1951	Victoreen	313/93
2,577,106	12/1951	Coleman	250/389
2,596,080	5/1952	Raper et al.	313/93
2,837,677	6/1958	Hendee et al.	250/374
3,576,439	4/1971	Figueroa	250/370
3,742,230	6/1973	Spears et al.	250/510

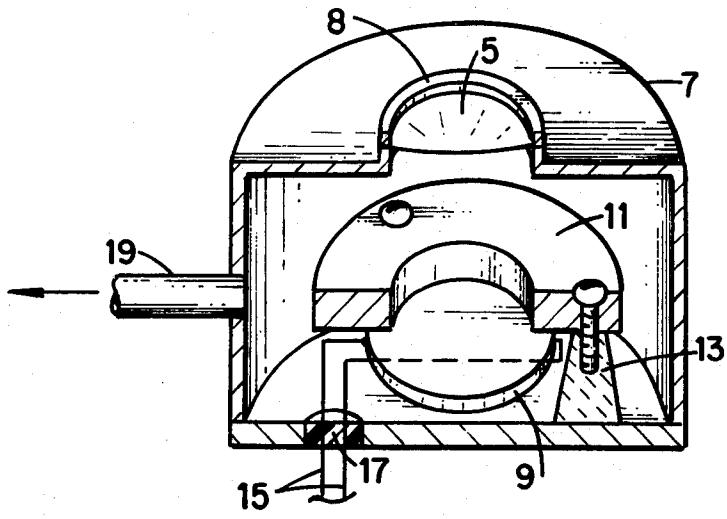
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[57] **ABSTRACT**

An improved x- and gamma- radiation and particle transparent window for the environment-controlling enclosure of various types of radiation and particle detectors is provided by a special graphite foil of a thickness of from about 0.1 to 1 mil. The graphite must have very parallel hexagonal planes with a mosiac spread no greater than 5° to have the necessary strength in thin sections to support one atmosphere or more of pressure. Such graphite is formed by hot-pressing and annealing pyrolytically deposited graphite and thereafter stripping off layers of sufficient thickness to form the window.

2 Claims, 2 Drawing Figures



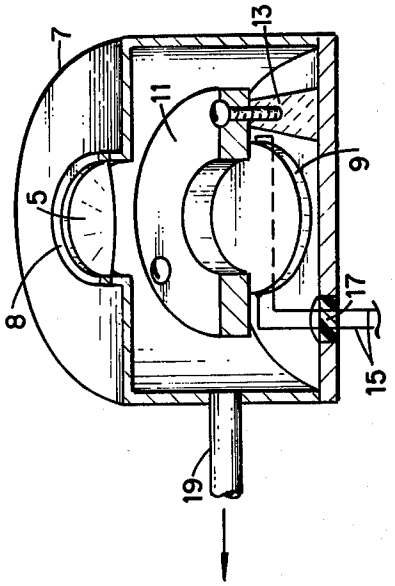


Fig. 1

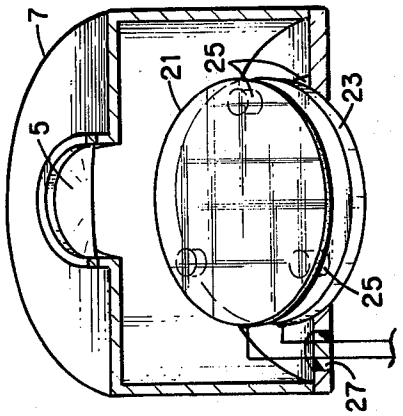


Fig. 2

WINDOW FOR RADIATION DETECTORS AND THE LIKE

This invention was made during the course of, or under, a contract with the United States Atomic Energy Commission.

BACKGROUND OF THE INVENTION

This invention relates generally to ionizing radiation detectors and more specifically to radiation detectors of the type having an environment-controlling enclosure with a radiation transparent window therein.

many types of detectors for ionizing radiation, such as neutrons, charged particles, gammas or x-rays, are provided with an enclosure whereby the active detector element may be maintained in a vacuum or a desired gaseous environment. However, in order for the ionizing radiation or particle to reach the detecting element, a "window" must be provided which will admit the radiation or particle and, at the same time, maintain the environment around the detector which may include the exclusion of light or infrared photons for certain type detectors such as the silicon diode.

A typical example of this construction is a solid state detector for x-rays. A Si(Li) detector is mounted in a housing so as to be cryogenically cooled, and a vacuum of about 10^{-6} Torr is maintained around the detecting element. A thin (usually 1 mil) beryllium foil covers a circular window opening in the housing having a diameter of about 0.25 to 0.5 in. Beryllium has been utilized in the prior art because its low atomic number and high tensile strength gave the better relative transparency, compared to other materials, to the radiation to be detected, especially soft x-rays. Commercial beryllium after hot rolling to thin foils suitable for detector windows is normally about 98% pure; some of the principal impurities are iron, nickel and copper. However, if as much as 0.3 wt % Cu is present, the absorption by the foil is increased by a factor of 2 or more for low energy radiations, i.e., the most strongly absorbed radiation and, therefore, less intense radiation is best benefited by reduction of impurities in the foils. This is the type of radiation utilized for x-ray fluorescence analysis.

Furthermore, the mounting of thin Be windows by brazing or glueing is generally considered to be difficult and failures in excess of 80% can occur during fabrication because of the brittleness of the beryllium and small holes. The 1-mil foil is most generally used but thicknesses to 0.5-mil of beryllium have been used successfully to withstand a one atmosphere of pressure differential but with an increased percentage of failures.

SUMMARY OF THE INVENTION

In view of the above, it is one object of the subject development to provide a thinner window for radiation detectors having a lower absorption for the radiation, particularly low energy radiation.

It is another object to provide a window that may be fabricated with greater success than that of the prior art thus reducing the cost.

Other objects and many of the attendant advantages of the present invention will become apparent from the following detailed description, taken in conjunction with the drawings, of a thin graphite window, of a thickness of about 0.1-mil, wherein the hexagonal (basal) crystal planes are substantially parallel to the surface of the foil providing an extemely high tensile strength.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a pictorial sectioned view of a solid state ionizing radiation detector utilizing the graphite foil window of the present invention.

FIG. 2 is a pictorial sectioned view of a gas-filled ionizing radiation detector utilizing the graphite foil window of the present invention.

DETAILED DESCRIPTION

It has been known in the prior art that a graphite body, having substantially parallel basal planes, can be prepared by hot-pressing and annealing pyrolytically-deposited graphite. These bodies have been utilized, for example, as x-ray and neutron diffraction targets, etc. The planes are about 3.35 A apart and have a mosaic spread of no more than 5° but generally 1° or less.

Because carbon is only a little more absorbing toward radiation (Atomic No. 6 versus 4) than is Be, and can be prepared in very pure form, thin layers of the highly oriented graphite were investigated as a window for detectors. Although a thickness of greater than 6 mils would be expected to be necessary to withstand the pressure differential based upon published strength data, theoretical strength calculations show that foils as thin as 160 A could possibly support one atmosphere of pressure over a hole of 0.5 in. diameter. Graphite foils of the order of 1-mil were first investigated in order to compare them with 1-mil Be foils.

These foils were prepared by lifting layers of the graphite from a pressed body in a manner similar to separating layers of mica. For example, an adhesive tape may be applied along an edge of the surface followed by a careful peeling up of the layer. The window is trimmed out of the portion not in contact with the tape and either clamped between flanges or glued to a flange for use in the detector system. The simple peeling method generally produces a foil of about 1-mil thickness. To prepare thinner foils, a "parting agent", such as water, is applied to the edge of the pressed body prior to a peeling step. This agent apparently works along the planes of the graphite body and foils of 0.1 to 0.2 mils are normally produced.

Graphite foils of various thickness were clamped between two flanges having a 0.25 in. diameter opening, using Teflon washers on each surface. These were subjected to a vacuum of up to 10^{-6} Torr on one side. Foils as thin as 0.1-mil withstood this pressure differential.

Referring now to FIG. 1 there is shown a radiation detector including the graphite foil window **5** of the present invention sealably mounted over an opening in the detector housing **7** by means of an annular flange **8.** This detector housing **7** encloses a solid state detecting element, such as a silicon diode **9.** Typically, the diode **9** is mounted at the back of an annular shield **11** which has a central opening smaller than the sensitive detection area to prevent deposition of energy in the peripheral regions of the diode where charge collection is incomplete thus reducing the energy of the pulse and contribution to the background.

The shield **11** and diode **9** assembly is mounted on insulators **13** within the housing **7** and the output leads **15** from the diode exit the housing through a sealed opening **17** in the housing back. A vacuum line connection **19** is provided to evacuate the housing **7** during radiation detection.

A detector of this type may be used with a radiation collimator (not shown) forward of the window **5** and the window is typically about 0.5 inch in diameter.

Referring now to FIG. **2** there is shown a detector of the gasfilled proportional counter type which has a housing **7** and graphite window **5** similar to the embodiment shown in FIG. **1.** The detector anode electrode is provided by means of a circular wire grid **21** and the cathode electrode is formed by an electrically conductive plate **23.** The grid **21** and plate **23** are spaced apart and supported within the housing **7** by means of insulator mounts **25.** The electrical connections to the electrodes are made via a sealed opening **27** in the housing **7.** Typically, a counter of this type is filled with a pressurized ionizable gas to a pressure of about 1 atmosphere.

The theoretical transmission of the characteristic x-rays of several elements has been compared with that for Be windows. These calculations indicate that the transmission of a 0.1-mil graphite foil is about the same as for a 0.33 mil high purity beryllium foil. Thus, a 0.1-mil graphite window may transmit about three times as much x-radiation at energies less that 1 KeV as a 1-mil high purity (>99.9%) Be foil. The table below shows the comparison of the fraction of various x-radiation energy transmitted (P_t) to that incident (P_o) for a **0.1** mil thick graphite window and a **1**-mil thick Be window using known absorption coefficients.

TABLE

Energy	Graphite Foil, 0.1 mil	Beryllium Foil, 1 mil
KeV	P_t/P_o	P_t/P_o
0.4	1.3×10^{-5}	10^{-10}
0.67	0.054	0.0017
1.0	0.455	0.192
2.0	0.884	0.78
4.5	1.0	1.0

Since a thin Be foil has about 2% impurities, in actual practice the 0.1-mil graphite is about 10 times more transparent and does not exhibit the many absorption edges which arise from the impurities in Be and which cause difficulties in operation as each absorption edge must be determined.

Other calculations have been made of the apparent and expected strength of the graphite foils. The calculations indicate the strength in the plane of the basal sheets to be in excess of 2000 Kg/cm^2, considerably higher than published values for hot-pressed pyrolytic graphite but near the values published for graphite fibers. This result predicts that very thin foils of a thickness of 0.1-mil will support one atmosphere of pressure.

Accordingly it will be seen that an improved ionizing radiation detector window has been provided by employing a graphite foil produced from pyrolytically deposited hot-pressed and annealed graphite.

What is claimed is:

1. In an ionizing radiation detector including a housing having a radiation pervious window therein, the improvement comprising: said window being a graphite foil formed from pyrolytically-deposited hot pressed and annealed graphite.

2. The detector as set forth in claim **1** wherein said housing having an atmosphere therein at a pressure producing a pressure differential across said window of about 1 atmosphere and wherein said graphite foil window has a uniform thickness in the range of from about 0.1 to 1 mil.

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