US000001500H

United States Statutory Invention Registration [19]

[11] **Reg. Number: H1500**

[45] **Published: Nov. 7, 1995**

Kronenberg

[54] **ULTRA-SENSITIVE CARBON FIBER DOSIMETER**

[75] Inventor: **Stanley Kronenberg**, Skillman, N.J.

[73] Assignee: **The United States of America as represented by the Secretary of the Army**, Washington, D.C.

[21] Appl. No.: **167,258**

[22] Filed: **Dec. 15, 1993**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 21,427, Feb. 23, 1993, abandoned.

[51] **Int. Cl.**[6] **G01T 1/14**; H01J 47/04

[52] **U.S. Cl.** **250/376**

[58] **Field of Search** 250/376

[56] **References Cited**

U.S. PATENT DOCUMENTS

2,648,777	8/1953	Landsverk	250/376
2,793,298	5/1957	Landsverk	250/376
4,306,154	12/1981	Williams, Jr. et al.	250/376

OTHER PUBLICATIONS

H. H. Rossi, "Status of Neutron Dosimetry", *Nucleonics*, vol. 10, No. 9, (Sep. 1952) pp. 26–27.

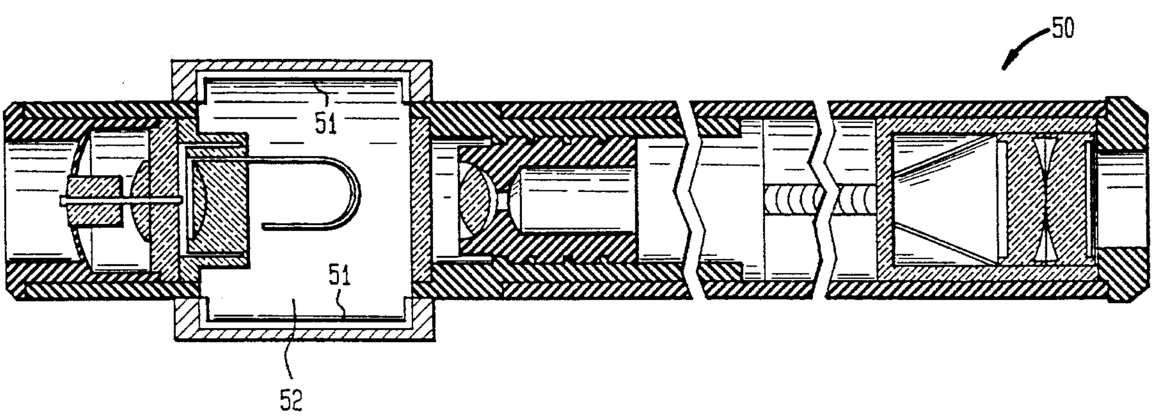
Primary Examiner—Bernarr E. Gregory

Attorney, Agent, or Firm—Michael Zelenka; James A. DiGiorgio

[57] **ABSTRACT**

A 20 mR (5.16 * 10^{-3} C/Kg) full-scale carbon fiber dosimeter that provides a direct reading of low-level Gamma and neutron exposure in real-time. To attain this, the dosimeter utilizes an enlarged ionization chamber that has a cylindrical shape with an inside diameter at least 1 inch (2.54 cm), an outside diameter at least 1.1 inches (2.794 cm), an inside height at least 0.725 inch (1.8415 cm), and an outside at least 1 inch (2.54 cm). Moreover, the inner wall of the dosimeter's ionization chamber is lined with either a predetermined hydrogenous or non-hydrogenous material having different sensitivity to gamma ray and neutron exposure.

3 Claims, 3 Drawing Sheets



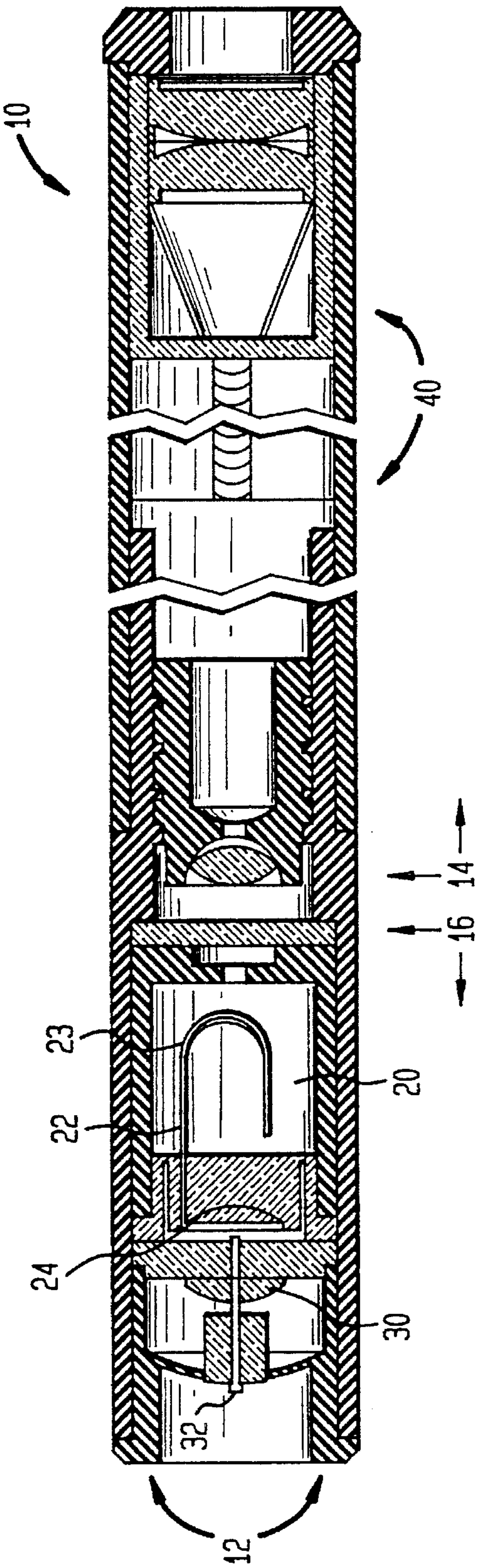


FIG. 1
(PRIOR ART)

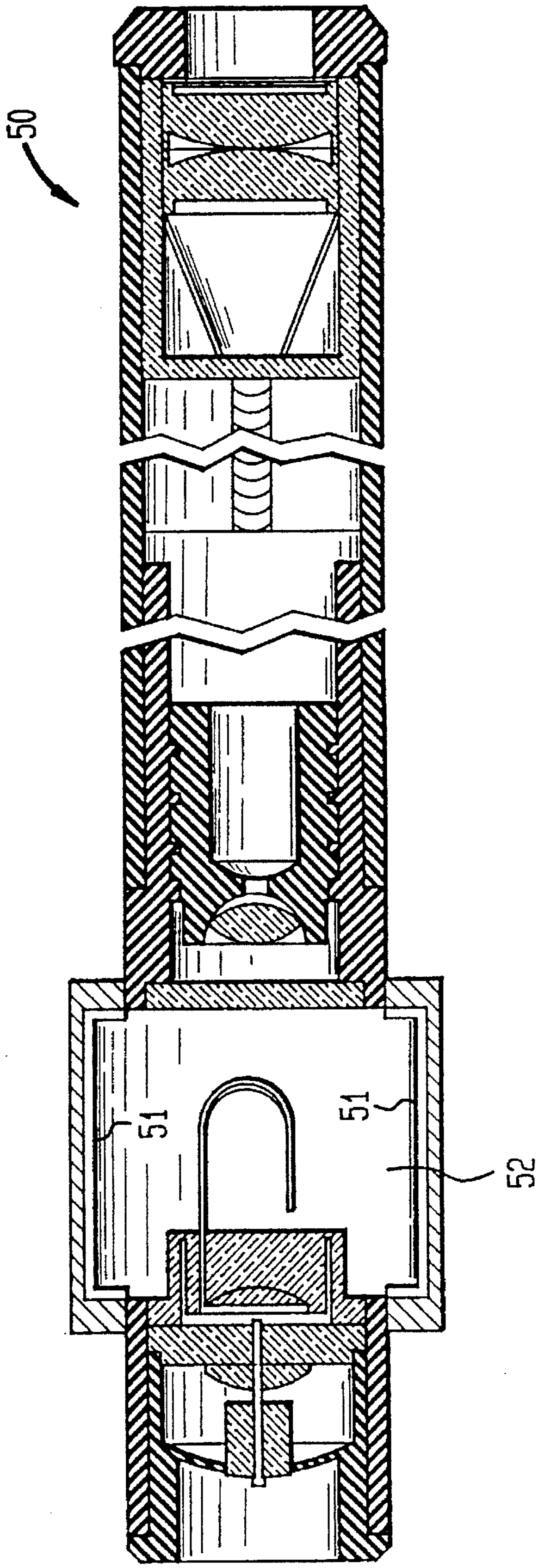


FIG. 2

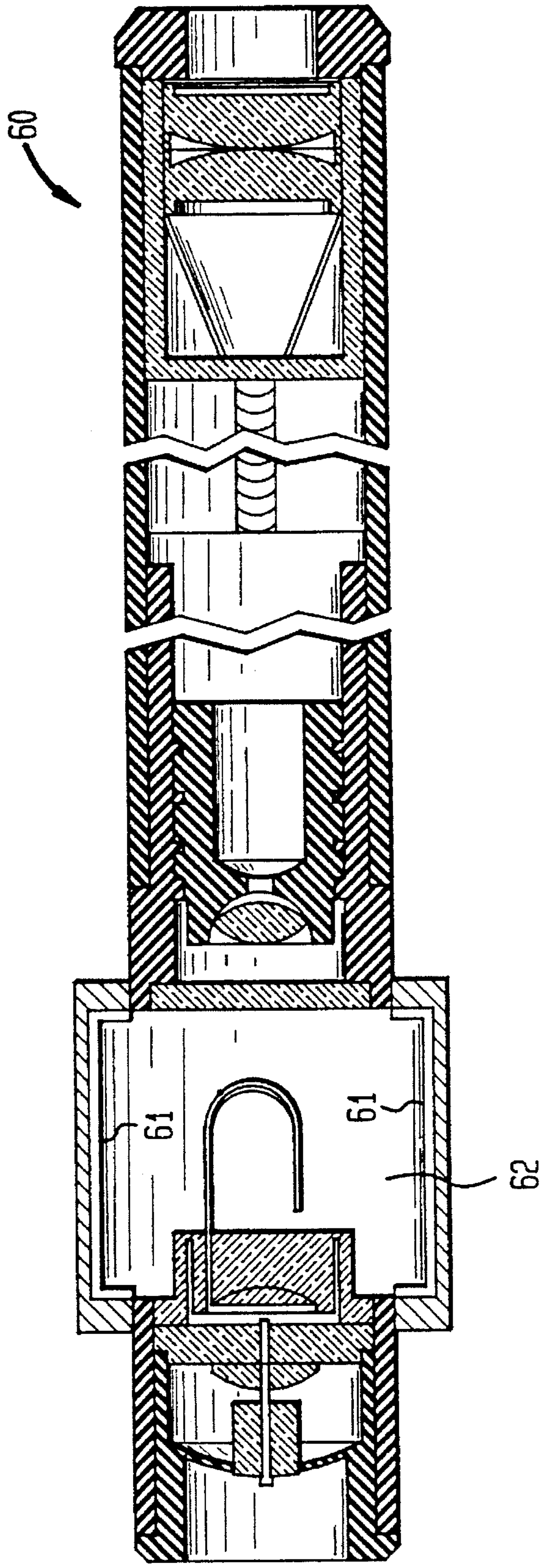


FIG. 3

ULTRA-SENSITIVE CARBON FIBER DOSIMETER

GOVERNMENT INTEREST

The invention described herein may be manufactured, used and licensed by or for the Government for governmental purposes without the payment to me of any royalty thereon.

NOTICE OF CONTINUATION

This application is a continuation-in-part of application Ser. No. 08/021,427, entitled 20 mR FULL SCALE CARBON FIBER DOSIMETER, by S. Kronenberg, Attorney Docket No. CECOM 4878, filed Feb. 23, 1993.

BACKGROUND OF THE INVENTION

The present invention relates to nuclear radiation measuring devices of the type used to measure the amount of radiation exposure delivered over a period of time. More specifically, it relates to an improved direct-reading dosimeter for providing both a combined and a separate measurement of low-level gamma and neutron exposure.

As nuclear technology has become more widespread in our society, so has the desire for radiation measuring devices that can detect even the slightest levels of exposure that an individual has received over any given time. Moreover, those handling radioactive materials for testing and developing nuclear technology and those exposed to nuclear weaponry, nuclear power plants, and workers in the field of nuclear medicine, have long recognized the need for a dosimeter that can measure radiation doses at levels as low as the known average daily background level.

Currently, there are few devices that can conveniently and inexpensively provide such low-level measurements. One device, a Photo-Multiplier/Scintillator System utilizes the immediate conversion of ionizing radiation energy into visible light energy to measure radiation exposure. Another device, a thermoluminescent dosimeter, utilizes thermoluminescent materials (e.g. LiF) to detect exposure levels. In such a device, radiation raises the electrons in the thermoluminescent material to an excited energy level. These electrons remain excited until the material is exposed to high temperature. Consequently, radiation exposure levels can be determined by heating the exposed crystals and measuring the amount of light emitted as the excited electrons drop back to their ground state. To those who desire quick measurements, in real time, while they operate in an environment suspect of radiation, both the Scintillator System and the thermoluminescent dosimeter are inadequate (inconvenient and time consuming).

A more preferred method of measuring exposure in real time is a direct-reading dosimeter or exposure meter. One such device, a 200 mR ($5.16 * 10^{-2}$ C/Kg) Carbon Fiber Dosimeter, is disclosed in U.S. Pat. No. 4,306,154, issued Dec. 15, 1981 by Williams et al and incorporated herein by reference. This device utilizes an ionization chamber, an electrically charged fiber electrometer, and a viewing means to measure exposure. Radiation passing through the ionization chamber discharges the electrometer, thereby moving the charged electrometer fiber in proportion to the amount of radiation passing through the chamber. Thus, an individual wearing the dosimeter can determine his own exposure by simply looking through the viewing means at the electrometer fiber deflection at any time.

Although this device is quick and convenient for measuring personal exposure, it does not provide the sensitivity needed to accurately measure the low levels that may be encountered in a suspect environment (e.g. nuclear contaminations area). This is fully evident in that the above device provides full scale readings of 200 mR ($5.16 * 10^{-2}$ C/Kg), wherein a background exposure dose rate is typically in the range of 0.014 mR/hr ($3.612 * 10^{-6}$ C/Kg/hr). As such, those concerned with measuring exposure levels in such environments suspect of radiation, have long recognized a need for a dosimeter that provides the convenience of the 200 mR ($5.16 * 10^{-2}$ C/Kg) Full Scale Carbon Fiber Dosimeter but with greater sensitivity to lower exposure levels.

A similar device was disclosed in U.S. Pat. No. 2,648,777, entitled "Quartz Fiber Dosimeter," issued to O.G. Landsverk on Aug. 11, 1953, and incorporated herein by reference. The Landsverk device utilizes a quartz fiber, mounted in an air chamber, that functions to indicate the real time dosage level. The chamber wall is lined with hydrogenous material having an average atomic number of 7.2 (which is the average atomic number of air), and thus provides readings in roentgens. The hydrogenous chamber wall also makes the Landsverk dosimeter sensitive to fast neutrons, and thus gives a composite reading of the gamma ray exposure and the neutron exposure. This is not desirable when separate real-time readings of the gamma dosage and the neutron dosage are required.

Although it has been known for quite some time that certain materials have different levels of sensitivity to gamma and neutron exposure, there is no existing device that has properly taken advantage of such technology to provide separate measurements of the gamma and neutron exposure. See "Status of Neutron Dosimetry," by H. H. Rossi, published in Nucleonics, September, 1952, and incorporated herein by reference. All existing devices provide a composite reading of the gamma and neutron dosage.

Therefore, it is proposed that a device that properly takes advantage of the different sensitivities inherent in different materials can provide both a combined and a separate gamma and neutron dose measurements in real-time. Moreover, a device that can provide even greater sensitivity to such gamma and neutron exposure levels is greatly desired by those skilled in the art. The present invention fulfills these needs.

SUMMARY OF THE INVENTION

The general purpose of the invention is to provide a direct-reading carbon fiber dosimeter that can accurately measure low-level gamma ray and neutron exposure in real-time. To attain this, the present invention contemplates increasing the chamber size of a carbon fiber dosimeter such that its sensitivity is 20 mR ($5.16 * 10^{-3}$ C/Kg) full scale.

In one embodiment of the invention, the wall of the enlarged chamber is lined with a predetermined non-hydrogenous material so that only gamma and soft X-ray exposure is measured. In other words, the dosimeter measures the composite of the gamma ray and soft X-ray exposure.

In another embodiment of the invention, the wall of the enlarged chamber is lined with a predetermined hydrogenous material so that the gamma and fast neutron exposure is measured. In other words, the dosimeter measures the composite of both.

It is another object of the invention to provide a means for obtaining a separate real-time measurement of the gamma ray exposure and the neutron exposure. To attain this, the present invention contemplates utilizing both the hydrogenous and non-hydrogenous measurements, simultaneously, so that the amount of exposure due only to neutron radiation can be determined.

According to yet another aspect of the invention, the sensitivity of the dosimeter is increased even further by rearranging the optics of the viewing means (built-in microscope). More specifically, the fiber and its deflection are magnified by reducing the distance between the carbon fiber and the objective lens while increasing the distance between the objective and ocular lens.

According to yet another aspect of the invention, the sensitivity is increased by combining the effect of increasing the ion chamber volume with the effect of rearranging the optics of the viewing means as described above. This combination can achieve an even greater sensitivity (5 mR ($1.29 * 10^{-2}$ C/Kg) full scale).

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a longitudinal cross-sectional view of the prior art.

FIG. **2** is a longitudinal cross-sectional view of a preferred embodiment of the invention showing the enlarged ion chamber that displaces the barrel, wherein the chamber wall is lined with hydrogenous material.

FIG. **3** is a longitudinal cross-sectional view of another embodiment of the invention showing the enlarged ion chamber that displaces the barrel, wherein the chamber wall is lined with a predetermined non-hydrogenous material.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. **1**, there is shown prior art carbon fiber dosimeter **10** upon which the present invention has improved. Prior art dosimeter **10** comprises a tubular shaped casing or barrel **12** having upper and lower sections **14** and **16**, respectively. Dosimeter **10** is of a size and shape that can easily be carried in a shirt pocket. Lower section **16** of barrel **12** contains a cylindrical ionization chamber **20** which comprises an electrometer **22** having a frame **24**. A charging means **30** having a charging pin **32** connects to electrometer **22** so that the chamber and electrometer can be fully charged prior to taking any readings. Thus, when radiation passes through chamber **20**, chamber **20** and electrometer **22** are discharged in proportion to the amount radiation that passes through. As chamber **20** and electrometer **22** discharge, carbon fiber **23** moves in proportion to the discharge indicating the exposure level. This level can be viewed through optical means **40** located in upper section **14** of barrel **10**. Due to the size and shape of ionization chamber **20**, however, deflection of carbon fiber **23** is limited to 200 mR (5.16 $* 10^{-2}$ C/Kg) full scale sensitivity.

Referring to FIG. **2**, there is shown an improved dosimeter **50**, in accordance with the present invention. In addition to the elements of dosimeter **10**, dosimeter **50** has a cylindrical ionization chamber **52** with a volume larger than that of chamber **20**. More specifically, chamber **52** has an inside diameter of 1 inch (2.54 cm), an outside diameter of 1.1 inches (2.794 cm) and a height of 0.725 inch (1.8415 cm) inside and 1 inch (2.54 cm) outside. This increase in volume greatly enhances the measuring sensitivity of dosimeter **50** from 200 mR ($5.16 * 10^{2}$ C/Kg) to 20mR ($5.16 * 10^{-3}$ C/Kg) full scale.

Referring to FIG. **3**, there is shown device **60** which is similar to device **50**, in FIG. **2**, except that the inside wall of each chamber **60** and **50** are lined with different material. The inside wall of chamber **60** is lined with a predetermined non-hydrogenous material (hydrogen-free TEFLON®) **61** that is only sensitive to gamma rays, whereas the inside wall of chamber **50** is lined with a predetermined hydrogenous material (polyethylene) **51** that is sensitive to both gamma rays and neutrons. As a result, separate measurements of the gamma dose and the neutron dose can be derived from the simultaneous measurement of the real-time dosage with dosimeter **50** and **60**.

More specifically, the readings from dosimeter **50** and **60** provide two equations (R1 and R2) with two unknowns (Dgamma and Dneutron), as shown below:

$$R1 = D\text{gamma} * S1\text{gamma} + D\text{neutron} * S1\text{neutron}$$

$$R2 = D\text{gamma} * S2\text{gamma} + D\text{neutron} * S2\text{neutron}$$

"Dgamma" is the actual gamma-ray dosage and "Dneutron" is the dosage due to neutron radiation to which dosimeters **50** and **60** are exposed. "R1" is the reading from dosimeter **50** which has hydrogenous chamber wall **51**, and "R2" is the reading from dosimeter **60** which has non-hydrogenous chamber wall **61**. "S1gamma" and "S1neutron" refer to dosimeter **50**'s sensitivity to the gamma and neutron exposure, respectively. "S2gamma" and "S2neutron" refer to dosimeter **60**'s sensitivity of the gamma and neutron dosage, simultaneously.

Since dosimeter **50** utilizes a polyethylene lining **51** and dosimeter **60** utilizes a hydrogen-free TEFLON® lining **61**, each dosimeter has the same sensitivity to gamma rays. Consequently, S1gamma equals S2gamma. Moreover, since dosimeter **60** has virtually no sensitivity to neutrons, S2neutron is negligible. As a result, the simultaneous equations can be simplified to the following:

$$D\text{neutron} = (R1 - R2)/S1\text{neutron}$$

$$D\text{gamma} = R2/S2\text{gamma}$$

Consequently, from the simultaneous measurement of radiation exposure with dosimeters **50** and **60**, the actual neutron dosage (Dneutron) and the actual gamma-ray dosage (Dgamma) can be determined since the sensitivity of each dosimeter to neutrons and gamma-rays are known (from the predetermined material lining their respective chamber walls.

What is claimed is:

1. A highly sensitive carbon fiber dosimeter that provides real-time measurements of radiation exposure including gamma rays and neutrons, comprising:

a tubular plastic barrel having an ionization chamber that provides the dosimeter with 20 mR full scale sensitivity to the radiation exposure, said ionization chamber having a cylindrical shape with an inside diameter of at least 1 inch (2.54 cm), an outside diameter of at least 1.1 inches (2.794 cm), an inside height of at least 0.725 inch (1.8415 cm);

said ionization chamber having an inner wall composed of a predetermined material having a predetermined sensitivity to the gamma rays and the neutrons.

2. The dosimeter of claim **1** wherein said predetermined material composing said inner wall of said ionization chamber is an hydrogenous material having a predetermined sensitivity to both the gamma ray and neutron components of the radiation exposure.

3. The dosimeter of claim **1** wherein said predetermined material composing said inner wall of said ionization chamber is a non-hydrogenous material having a predetermined sensitivity only to the gamma ray component of the radiation exposure.

* * * * *