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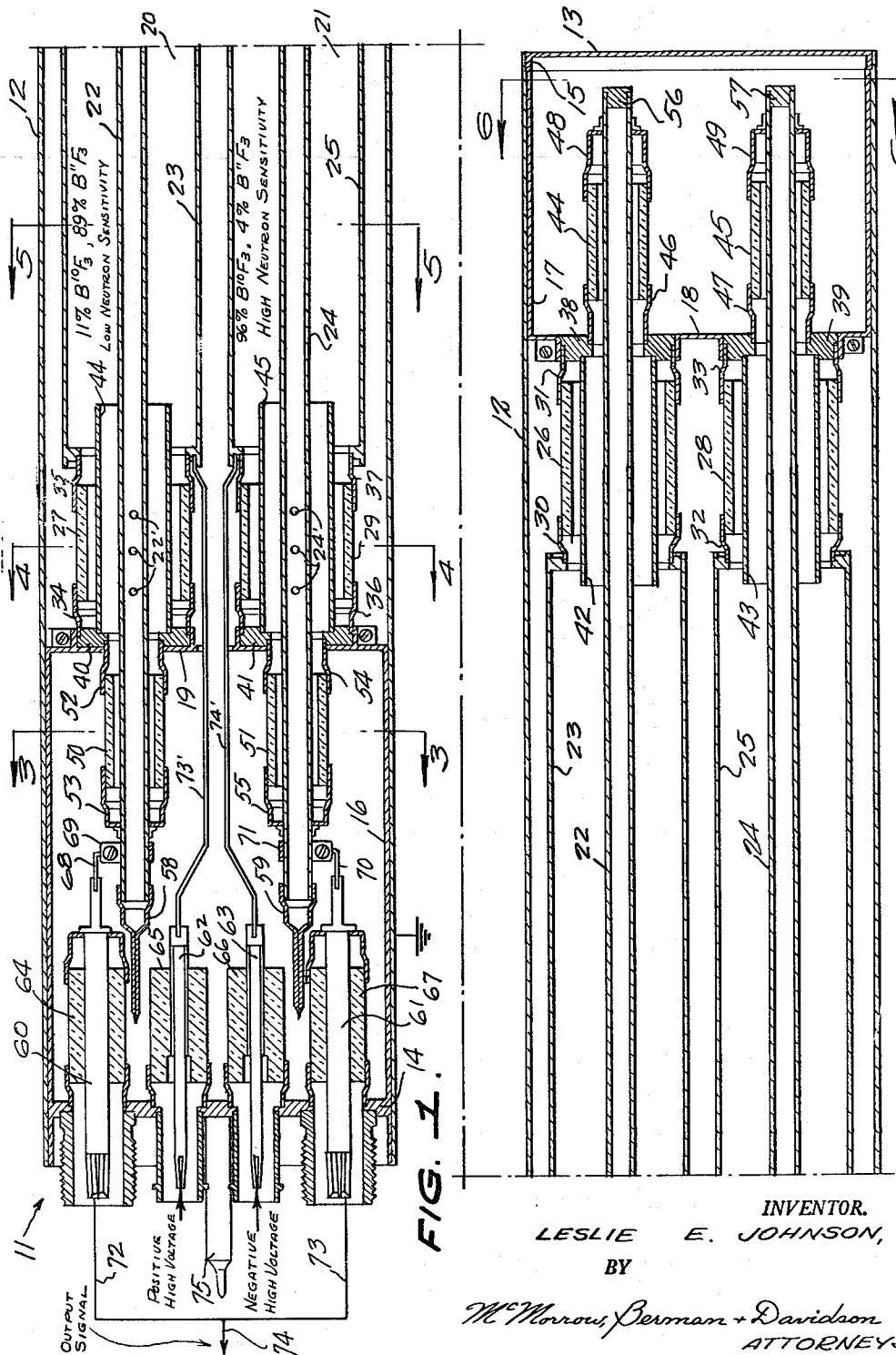
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2,976,418

GAMMA-COMPENSATED IONIZATION CHAMBER

Filed Nov. 22, 1957

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

FIG. 2.

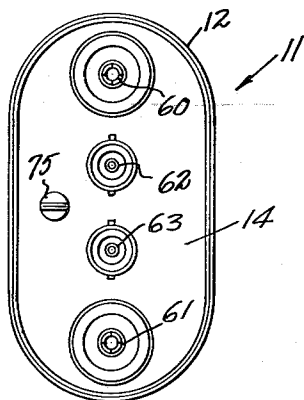


FIG. 3.

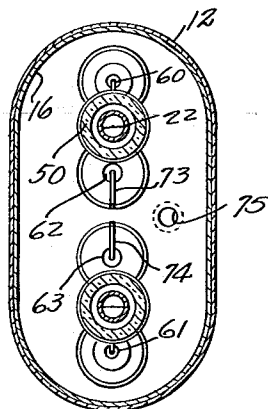


FIG. 4.

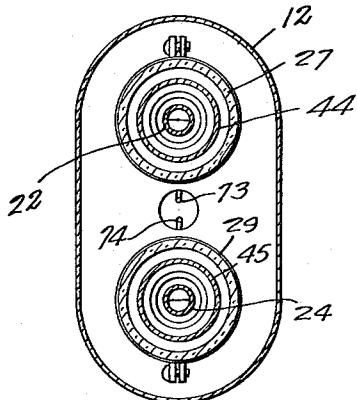


FIG. 5.

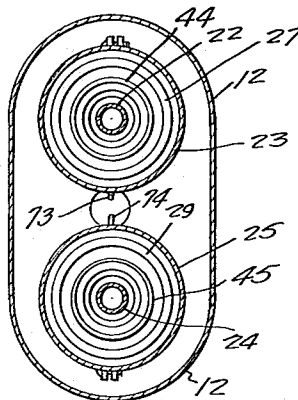
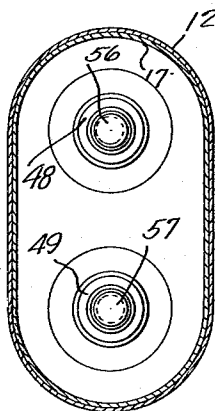


FIG. 6.



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GAMMA-COMPENSATED IONIZATION CHAMBER

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12 Claims. (Cl. 250—83.1)

This invention relates to ionization chambers, and more particularly to an ionization chamber highly sensitive to neutrons and provided with means for compensating for response to gamma radiation.

A main object of the invention is to provide a novel and improved ionization chamber especially adapted for the detection of neutrons and intended for use over a wide range of temperatures, the ionization chamber being relatively simple in construction, being relatively compact in size, and being arranged so that the effects of gamma radiation are substantially eliminated and the response of the chamber will be limited essentially to response to neutrons.

A further object of the invention is to provide an improved ionization chamber adapted for use at relatively high temperatures and highly sensitive to the presence of neutrons, the chamber being provided with means for substantially eliminating the effects of gamma radiation, the chamber being relatively inexpensive to manufacture, being durable in construction, and involving relatively few parts.

A still further object of the invention is to provide an improved method of eliminating the effects of gamma radiation in quantitatively measuring the intensity of neutron radiation.

A still further object of the invention is to provide an improved system for quantitatively measuring the intensity of neutron radiation by employing ionization chambers utilizing neutron-sensitive gas fillings, the system being arranged to compensate for the presence of gamma radiation by the proper selection of the neutron-sensitive gas fillings in the respective ionization chambers.

Further objects and advantages of the invention will become apparent from the following description and claims, and from the accompanying drawings, wherein:

Figure 1 is a longitudinal vertical cross sectional view taken through a twin ionization chamber assembly constructed in accordance with the present invention.

Figure 2 is an end view of the ionization chamber assembly of Figure 1, seen from the terminal end of the assembly.

Figure 3 is a transverse vertical cross sectional view taken on the line 3—3 of Figure 1.

Figure 4 is a transverse vertical cross sectional view taken on the line 4—4 of Figure 1.

Figure 5 is a transverse vertical cross sectional view taken on the line 5—5 of Figure 1.

Figure 6 is a transverse vertical cross sectional view taken on the line 6—6 of Figure 1.

Referring to the drawings, 11 generally designates an ionization chamber assembly constructed in accordance with the present invention. The assembly 11 comprises an elongated metal outer casing or housing 12 provided with a first end wall 13 and with a second end wall 14, the end wall 13 having the peripheral flange 15 which is received in and sealingly secured to the inside surface of one end portion of the housing 12, and the end wall 14 being integrally formed in a liner 16 which is received

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in and sealingly secured to the opposite end of housing 12.

Secured in the casing 12 adjacent end wall 13 is a liner member 17 having the inner transverse wall 18. Similarly, the liner member 16 has an inner transverse wall 19.

Both of the liner members 17 and 16 are of metal and are thus electrically connected to the metal outer casing 12.

Designated respectively at 20 and 21 are a pair of ionization chambers which are provided in the main housing 12, the ionization chamber 20 comprising an elongated hollow electrode 22 which is axially mounted within a cylindrical sleeve electrode 23. The electrode 22 constitutes the signal electrode, and the sleeve electrode 23 is the element of the chamber to which the high energizing voltage is applied. Similarly, the ionization chamber 21 comprises an elongated hollow signal electrode 24 and a cylindrical sleeve electrode 25 in which the signal electrode 24 is axially disposed.

As shown in Figure 1, the cylindrical sleeve electrodes 23 and 25 are supported at their ends by the respective transverse wall elements 18 and 19 and are electrically insulated therefrom by suitable sleeve members 26, 27, and 28, 29 of refractory insulating material, such as alumina or the like, of a nature capable of withstanding high temperature conditions. The ends of the cylindrical electrodes 23 and 25 are also sealingly connected to the transverse wall elements 19 and 18 through the refractory insulating sleeves 26, 27, 28 and 29 through suitable metal connecting collars, such as the collars 30 and 31, 32 and 33, 34 and 35, and 36 and 37, shown in Figure 1. The collar elements 31, 33, 34 and 36 are fastened to the peripheral portions of respective annular ring elements 38, 39, 40 and 41. Rigidly secured to the ring elements and electrically connected thereto are the respective inwardly extending metal guard sleeves 42, 43, 44 and 45 which are arranged coaxially around the signal electrodes 22 and 24 and which project inwardly substantial distances within the end portions of the respective cylindrical electrodes 23 and 25, whereby the end portions of the cylindrical electrodes overlap the inner ends of the guard sleeves.

The guard sleeves 42 to 45 are thus electrically connected to the outer casing 12 through the ring members 38 to 41 and through the associated transverse wall elements 18 and 19.

As shown in Figure 1, the signal electrodes 22 and 24 project substantial distances on opposite sides beyond the transverse wall elements 18 and 19. The ends of the signal electrodes adjacent the wall element 18 are supported therefrom by means of refractory insulating sleeves 44 and 45. The sleeves 44 and 45 are sealingly connected to the annular ring elements 38 and 39 by metal collar or sleeve members 46 and 47. The opposite ends of the insulating sleeves 44 and 45 are sealingly connected to the end portions of the signal electrodes 22 and 24 by annular metal cup elements 48 and 49.

The end portions of the signal electrodes 22 and 24 are secured to the transverse wall element 19 through refractory insulating sleeves 50 and 51 which are sealingly secured between the transverse wall element 19 and the respective end portions of the signal electrodes 22 and 24. Thus the refractory insulating sleeve 50 is sealingly secured at one end to the annular ring member 40 by a metal collar 52, whereas the opposite end of the insulating sleeve 50 is sealingly secured to the signal electrode 22 by an annular metal cup member 53. In the same manner, one end of the sleeve 51 is sealingly secured to the annular ring member 41 by a metal collar 54 and the opposite end of the insulating sleeve 51 is sealingly secured to the signal electrode 24 by an annular cup member 55.

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The hollow tubular electrodes 22 and 24 are formed with apertures 22' and 24' adjacent the insulating sleeves 27 and 29. The electrodes are provided with metal sealing plugs 56 and 57 at the ends thereof adjacent the casing end wall 13 and are provided at their opposite ends with filling caps 58 and 59 for admitting ionizable gas into the chambers, said caps being subsequently crimped, as shown.

Mounted in the end wall 14 and suitably insulated therefrom are the respective signal terminal prongs 60 and 61 and the respective high voltage terminal prongs 62 and 63. The terminal prongs are sealingly secured to the end wall 14 and insulated therefrom by insulating sleeves 64, 65, 66 and 67 of suitable refractory insulating material, such as alumina, or the like, having the ability to withstand high temperature conditions.

The inner end of the signal terminal prong 60 is electrically connected to signal electrode 22 by a conductor 68 and its associated contact clamp 69, and the signal terminal prong 61 is similarly electrically connected to the signal electrode 24 by a conductor 70 and its associated contact clamp 71. The inner end of the high voltage terminal prong 62 is connected by a conductor 73' to the adjacent end of cylindrical electrode 23, and the inner end of the high voltage terminal prong 63 is connected by a conductor 74' to the end of the cylindrical electrode 25, as shown in Figure 1.

The end wall 14 is provided with a suitable filling tube 75 for admitting an inert gas such as dry nitrogen, or the like, into the main housing 12.

Main housing 12 is grounded or is placed at any other suitable reference potential desired.

It will be understood that the filling tube 75 is suitably crimped and hard soldered after the inert gas has been introduced into the main housing, so that the gas will be thereafter retained in the housing.

The casing 12 is filled with a suitable inert gas, such as dry nitrogen, or the like, which thus surrounds the ionization chambers 20 and 21. The chambers 20 and 21 are filled with respective gaseous materials having different neutron sensitivities but having substantially equal gamma sensitivities. Thus, ionization chamber 20 may be filled with a gaseous material having low neutron sensitivity, whereas the chamber 21 may be filled with a gaseous material having high neutron sensitivity, the gaseous materials being selected to have substantially equal gamma sensitivities. For example, the chamber 20 may be filled with a mixture of gaseous compounds such as a mixture of the fluorides of different isotopes of boron, such as a mixture of the B¹⁰ fluoride and the B¹¹ fluoride, for example, a mixture comprising 11% of the B¹⁰ fluoride and 89% of the B¹¹ fluoride, said mixture having relatively low neutron sensitivity because of the relatively low percentage of the B¹⁰ fluoride. The chamber 21 is filled with a gaseous material having relatively high neutron sensitivity, for example, a mixture of the same boron isotope fluorides but in different proportion. For example, the gaseous mixture in the ionization chamber 21 may comprise 96% B¹⁰ fluoride and 4% B¹¹ fluoride, whereby the gaseous mixture in the chamber 21 has relatively high neutron sensitivity. However, the gaseous mixtures in both of the chambers 20 and 21 have substantially equal gamma sensitivities, whereby the signal electrodes 22 and 24 receive a substantially equal response to a given level of gamma radiation, but receive different responses to the presence of a given number of neutrons.

Respective high voltages of different polarities with respect to the ground or reference potential of casing 12 are applied to the respective high voltage terminal prongs 62 and 63. For example, a positive high voltage is applied to the terminal prong 62 and a negative high voltage is applied to the terminal prong 63. The device will work equally well with the potentials reversed.

The signal output terminal prongs 60 and 61 are connected by respective wires 72 and 73 to a common signal

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terminal 74, whereby the signal responses of electrodes 22 and 24 are combined. Since the responses are opposite in polarity, the components of said responses derived from gamma radiation will substantially cancel each other and the net signal available at the output terminal 74 will then be in accordance with the difference between the neutron responses of the signal electrodes 24 and 22. Thus, the response of signal electrode 22 to neutrons is subtracted from the neutron response of the signal electrode 24, since these electrodes are electrically connected together by the wires 72 and 73, providing a resultant signal at the output terminal 74 which will be in accordance with the number of neutrons present.

As will be readily apparent, the method herein disclosed for eliminating the effects of gamma radiation does not require that the ionization chambers be located in the same housing, but the method may be carried out in any system provided with twin ionization chambers having gaseous fillings of different neutron sensitivity and substantially equal gamma sensitivity, even though the chambers be physically separated, as long as their outer casings are at the same reference potential and maintained in a substantially equal gamma flux. It will also be apparent that any suitable mixture of gases may be employed as long as the gases have different neutron sensitivities and substantially equal gamma sensitivities.

It will be further understood that the high voltages applied to the terminal prongs 62 and 63 are of substantially the same magnitude, although of opposite polarity with respect to the reference potential on the casing 12.

While a specific embodiment of a system for obtaining a signal response in accordance with the number of neutrons present, and for substantially eliminating the effects of gamma radiation, has been disclosed in the foregoing description, it will be understood that various modifications within the spirit of the invention may occur to those skilled in the art. Therefore, it is intended that no limitations be placed on the invention except as defined by the scope of the appended claims.

What is claimed is:

1. In a system for measuring neutrons, a first ionization chamber having a relatively high neutron sensitivity, a second ionization chamber having a relatively low neutron sensitivity, each of said chambers comprising a signal electrode and a sleeve electrode surrounding said signal electrode, said chambers having substantially equal sensitivities to gamma radiation, said chambers being enclosed in a common conductive housing, a filling of inert gas in said common housing, means applying a high positive voltage to one sleeve electrode, means applying a high negative voltage to the other sleeve electrode, and means connecting the signal electrodes together, whereby the effects of gamma radiation on the chambers are substantially canceled and a resultant signal is provided at the connected signal electrodes in accordance with the difference between the responses of the chambers to the presence of neutrons.

2. In a system for measuring neutrons, a first ionization chamber containing a mixture of gaseous isotope compounds, one of which has a high neutron sensitivity and the other of which has low neutron sensitivity, a second ionization chamber containing a mixture of gaseous isotope compounds one of which has high neutron sensitivity and the other of which has low neutron sensitivity, each of said chambers comprising a signal electrode and a sleeve electrode surrounding said signal electrode, the mixtures of gaseous isotope compounds having substantially equal sensitivities to gamma radiation, the mixture in one of the chambers having a substantially greater percentage of high neutron sensitivity gaseous isotope compound than the mixture in the other chamber, said chambers having common outer conductive housing means at a common electrical potential, a filling of in-

ert gas in said common conductive housing means, means applying a high positive voltage to one sleeve electrode, means applying a high negative voltage to the other sleeve electrode, and means connecting the signal electrodes together, whereby the effects of gamma radiation on the chambers are substantially canceled and a resultant signal is provided at the connected signal electrodes in accordance with the difference between the responses of the chambers to the presence of neutrons.

3. In a system for measuring neutrons, a first ionization chamber containing a mixture of fluorides of boron isotopes, one of which has a high neutron sensitivity and the other of which has low neutron sensitivity, a second ionization chamber containing a mixture of fluorides of boron isotopes one of which has high neutron sensitivity and the other of which has low neutron sensitivity, each of said chambers comprising a signal electrode and a sleeve electrode surrounding said signal electrode, the mixtures of boron isotope fluorides having substantially equal sensitivities to gamma radiation, the mixture in one of the chambers having a substantially greater percentage of high neutron-sensitivity boron isotope fluoride than the mixture in the other chamber, said chambers having common outer conductive housing means at a common electrical potential, a filling of inert gas in said common conductive housing means, means applying a high positive voltage to one sleeve electrode, means applying a high negative voltage to the other sleeve electrode, and means connecting the signal electrodes together, whereby the effects of gamma radiation on the chambers are substantially canceled and a resultant signal is provided at the connected signal electrodes in accordance with the difference between the responses of the chambers to the presence of neutrons.

4. In a system for measuring neutrons, a first ionization chamber filled with a mixture of fluorides of boron isotopes including the fluoride of B^{10} isotope in a relatively high proportion, a second ionization chamber filled with a mixture of fluorides of boron isotopes including the fluoride of B^{10} isotope in a relatively low proportion, each of said chambers comprising a signal electrode and a sleeve electrode surrounding said signal electrode, said fluoride mixture having substantially equal sensitivities to gamma radiation, said chambers having common outer conductive housing means at a common electrical potential, a filling of inert gas in said common conductive housing means, means applying high potentials relative to said common potential of opposite polarity to said sleeve electrodes, and means connecting said signal electrodes together, whereby a resultant signal is obtained at the connected signal electrodes in accordance with the presence of neutrons and wherein the responses to gamma radiation are substantially canceled.

5. A neutron measuring device comprising a sealed main conductive housing, a pair of sealed ionization chambers in said housing, each ionization chamber comprising a tubular signal electrode, a sleeve electrode surrounding the signal electrode, and insulating sleeve means sealingly connecting the ends of the sleeve electrode to the end portions of the signal electrode, first ionizable gaseous material in one of the chambers, second ionizable gaseous material in the other chamber, said gaseous materials having substantially equal sensitivities to gamma radiation but having substantially different sensitivities to neutrons, a filling of inert gas in said main housing surrounding the ionization chambers and isolated from the gaseous material in the ionization chambers, means applying high voltages of opposite polarity to said sleeve electrodes, and means connecting the signal electrodes together, whereby the effects of gamma radiation on the chambers are substantially canceled, and whereby a resultant signal is provided at the connected signal electrodes in accordance with the difference between the responses of the chambers to the presence of neutrons.

6. A neutron measuring device comprising a sealed

main conductive housing, a pair of sealed ionization chambers in said housing, each ionization chamber comprising an elongated signal electrode, a sleeve electrode surrounding the signal electrode, insulating sleeve means sealingly connecting the ends of the sleeve electrode to the end portions of the signal electrode, respective conductive guard sleeves mounted in the end portions of the chamber concentrically between the insulating sleeve means and the signal electrode and projecting substantial distances into the end portions of the sleeve electrode, and means electrically connecting the guard sleeves to the main housing, first ionizable gaseous material in one of the chambers, second ionizable gaseous material in the other chamber, said gaseous materials having substantially equal sensitivities to gamma radiation but having substantially different sensitivities to neutrons, means applying high voltages of opposite polarity to said sleeve electrodes, and means connecting the signal electrodes together, whereby the effects of gamma radiation on the chambers are substantially canceled, and whereby a resultant signal is provided at the connected signal electrodes in accordance with the difference between the responses of the chambers to the presence of neutrons.

7. A neutron measuring device comprising a sealed main conductive housing, a pair of sealed ionization chambers in said housing, each ionization chamber comprising an elongated signal electrode, a sleeve electrode surrounding the signal electrode, insulating sleeve means sealingly connecting the ends of the sleeve electrode to the end portions of the signal electrode, respective conductive guard sleeves mounted in the end portions of the chamber concentrically between the insulating sleeve means and the signal electrode and projecting substantial distances into the end portions of the sleeve electrode, and means electrically connecting the guard sleeves to the main housing, first ionizable gaseous material in one of the chambers, second ionizable gaseous material in the other chamber, said gaseous materials having substantially equal sensitivities to gamma radiation but having substantially different sensitivities to neutrons, a filling of inert gas in said main housing surrounding the ionization chambers and being isolated from the gaseous materials in the ionization chambers, means applying high voltages of opposite polarity to said sleeve electrodes, and means connecting the signal electrodes together, whereby the effects of gamma radiation on the chambers are substantially canceled, and whereby a resultant signal is provided at the connected signal electrodes in accordance with the difference between the responses of the chambers to the presence of neutrons.

8. A neutron measuring device comprising a sealed main conductive housing, a pair of sealed ionization chambers in said housing, each ionization chamber comprising an elongated signal electrode, a sleeve electrode surrounding the signal electrode, insulating sleeve means sealingly connecting the ends of the sleeve electrode to the end portions of the signal electrode, a gaseous mixture of boron isotopes including the fluoride of B^{10} isotope in a relatively high proportion in one of the chambers, a gaseous mixture of boron isotopes including the fluoride of B^{10} in a relatively low proportion in the other chamber, said gaseous mixtures having substantially equal sensitivities to gamma radiation but having substantially different sensitivities to neutrons, a filling of inert gas in said main housing surrounding the ionization chambers and isolated from the gaseous mixtures in the ionization chambers, means applying high voltages of opposite polarity to said sleeve electrodes, and means connecting the signal electrodes together, whereby the effects of gamma radiation on the chambers are substantially canceled, and whereby a resultant signal is provided at the connected signal electrodes in accordance with the difference between the responses of the chambers to the presence of neutrons.

9. A neutron measuring device comprising a sealed

main conductive housing, a pair of sealed ionization chambers in said housing, each ionization chamber comprising an elongated signal electrode, a sleeve electrode surrounding the signal electrode, insulating sleeve means sealingly connecting the ends of the sleeve electrode to the end portions of the signal electrode, respective conductive guard sleeves mounted in the end portions of the chamber concentrically between the insulating sleeve means and the signal electrode and projecting substantial distances into the end portions of the sleeve electrode, and means electrically connecting the guard sleeves to the main housing, a gaseous mixture of boron isotopes including the fluoride of B¹⁰ isotope in a relatively high proportion in one of the chambers, a gaseous mixture of boron isotopes including the fluoride of B¹⁰ in a relatively low proportion in the other chamber, said gaseous mixtures having substantially equal sensitivities to gamma radiation but having substantially different sensitivities to neutrons, a filling of inert gas in said main housing surrounding the ionization chambers and isolated from the gaseous mixtures in the ionization chambers, means applying high voltages of opposite polarities to said sleeve electrodes, and means connecting the signal electrodes together, whereby the effects of gamma radiation on the chambers are substantially canceled, and whereby a resultant signal is provided at the connected signal electrodes in accordance with the difference between the responses of the chambers to the presence of neutrons.

10. A neutron measuring device comprising a sealed main conductive housing, a pair of sealed ionization chambers in said housing, each ionization chamber comprising an elongated signal electrode, a sleeve electrode surrounding the signal electrode, and insulating sleeve means sealingly connecting the ends of the sleeve electrode to the end portions of the signal electrode, first ionizable gaseous material in one of the chambers, second ionizable gaseous material in the other chamber, said gaseous materials having substantially equal sensitivities to gamma radiation but having substantially different sensitivities to neutrons, a filling of inert gas in said main housing surrounding the ionization chambers and being isolated from the gaseous materials in the ionization chambers, respective terminal members connected to said sleeve electrodes and adapted to be connected to different high voltage sources, and an output terminal connected to the signal electrodes, whereby a resultant signal is provided at said output terminal in accordance with the difference between the responses of the chambers to the presence of neutrons.

11. A neutron measuring device comprising a sealed main conductive housing, a pair of sealed ionization chambers in said housing, each ionization chamber comprising an elongated signal electrode, a sleeve electrode surrounding the signal electrode, insulating sleeve means sealingly connecting the ends of the sleeve electrode to

the end portions of the signal electrode, respective conductive guard sleeves mounted in the end portions of the chamber concentrically between the insulating sleeve means and the signal electrode and projecting substantial distances into the end portions of the sleeve electrode, and means electrically connecting the guard sleeves to the main housing, first ionizable gaseous material in one of the chambers, second ionizable gaseous material in the other chamber, said gaseous materials having substantially equal sensitivities to gamma radiation but having substantially different sensitivities to neutrons, respective terminal members connected to said sleeve electrodes, and an output terminal member connected to the signal electrodes, whereby a signal is provided at the output terminal in accordance with the difference between the responses of the chambers to the presence of neutrons.

12. A neutron measuring device comprising a sealed main conductive housing, a pair of sealed ionization chambers in said housing, each ionization chamber comprising an elongated signal electrode, a sleeve electrode surrounding the signal electrode, insulating sleeve means sealingly connecting the ends of the sleeve electrode to the end portions of the signal electrode, respective conductive guard sleeves mounted in the end portions of the chamber concentrically between the insulating sleeve means and the signal electrode and projecting substantial distances into the end portions of the sleeve electrode, and means electrically connecting the guard sleeves to the main housing, first ionizable gaseous material in one of the chambers, second ionizable gaseous material in the other chamber, said gaseous materials having substantially equal sensitivities to gamma radiation but having substantially different sensitivities to neutrons, a filling of inert gas in said main housing surrounding the ionization chambers and isolated from the gaseous materials in the ionization chambers, respective terminals connected to said sleeve electrodes and adapted to be connected to sources of different high voltage, and an output terminal member connected to the signal electrodes, whereby a resultant signal is provided at the output terminal member in accordance with the difference between the responses of the chambers to the presence of neutrons.

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