Dec. 15, 1959 W. C. DAVIDON 2,917,648

NUCLEAR RADIATION COUNTERS

Original Filed Jan. 7, 1953

FIG. 1

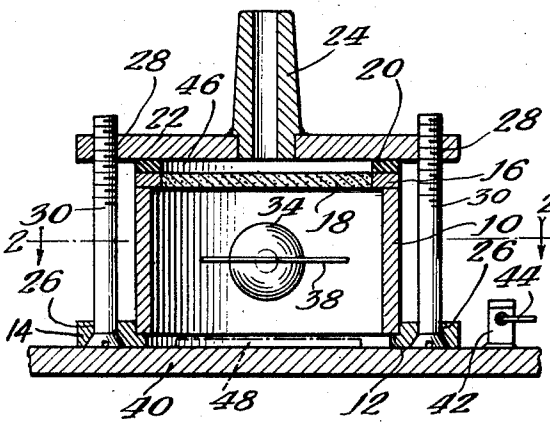


FIG. 2

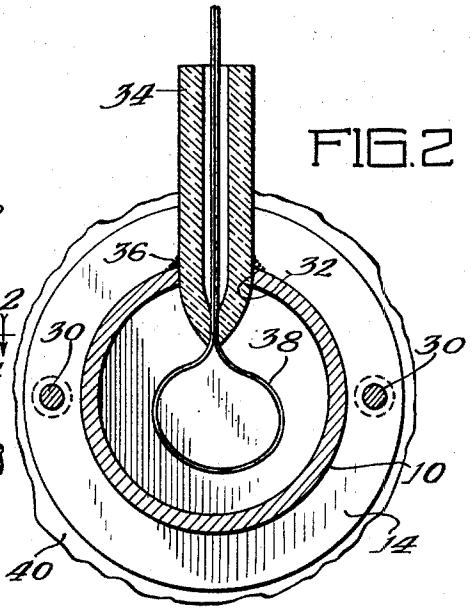


FIG. 3

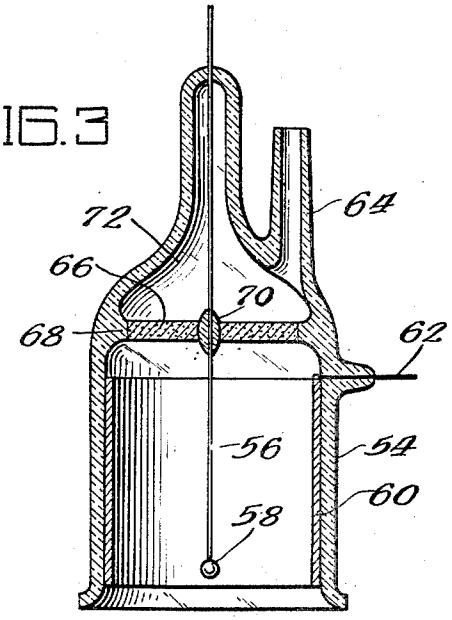


FIG. 4

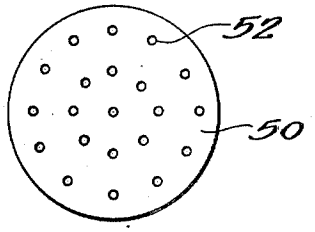
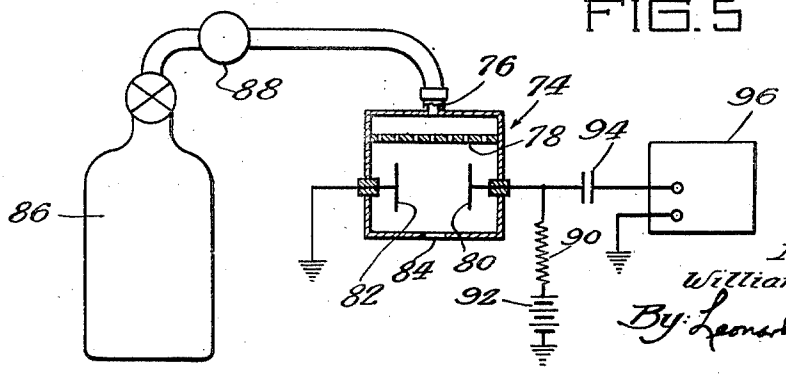


FIG. 5



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NUCLEAR RADIATION COUNTERS

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7 Claims. (Cl. 313—93)

This invention relates to nuclear radiation counters of the type wherein ionization of a gas by incident radiations is employed to produce ion-multiplication current pulses between electrodes disposed in the gaseous medium, and more specifically to the type of radiation counter in which the gas which serves as the ionizing medium is constantly flowed through the region between the electrodes. This is a continuation of an application of the same inventor filed January 7, 1953, Serial No. 330,055, now abandoned.

In counting radiations which are readily absorbed by small thicknesses of material, such as alpha particles or "soft" (low energy) beta particles, it is necessary in order to achieve high counting efficiencies that the sample of material under measurement be placed directly within the body of the radiation counter. There have for some time been available radiation counters designed for direct insertion of the samples under measurement into the counter body. In one type, the counter is constructed with a special type of gas lock through which the sample is introduced, thus introducing at the same time a minimum of air. The air thus introduced is flushed out by a flow of gas through the counter, which is provided with a gas inlet and outlet. The gas continues to flow through the counter at all times, the pressure of gas within the counter being slightly greater than atmospheric to provide egress, rather than ingress, of gas, so that small leakage in the joints and seals of the counter body may be tolerated without affecting counter operation. Because of the pressures at which the ionizing gases are maintained within the counter in such an arrangement, early use of such systems was confined to operation in the proportional region of the counter characteristics. However, there were subsequently developed counter gases which operate in the Geiger region at approximately atmospheric pressure and accordingly this type of counter, commonly known as a "flow counter," is now in use both as a proportional counter and as a G-M counter.

A number of problems are encountered with counters employing a gas lock to minimize the entry of air into the counter during insertion and removal of samples. The continuous flow of gas which is maintained serves to continuously sweep out any air entering the cavity of the counter by way of leaks, but the fabrication of suitable mechanism for introduction of samples nevertheless remains expensive. Furthermore, decontamination of counters of this type is rendered difficult by reason of the mechanical construction, since virtually complete disassembly is required in order to remove from the parts all vestiges of radioactive materials remaining from previous measurements; thus it is necessary to completely disassemble such counters periodically and to clean them in order to preserve the suitability of the counter for very sensitive measurements, which of course require the maintenance of extremely low background radiation.

Both because of the expense and because of the difficulty of decontamination mentioned above, there have

been developed counters in which the relatively complex gas locks are eliminated, but this has heretofore been done only at the expense of introducing into the counter, along with each change of sample, a large amount of air. In one type, a tubular counter open at the lower end is placed over a plate bearing the sample, and a gas inlet is provided at the top of the counter, the gas flowing downwardly and outwardly through the circularly dispersed leakage path which exists between the plate and the open mouth of the counter, no grease, gaskets, or other sealing means being employed. With this type of counter, it has been found necessary to flush gas through the counter for a substantial time after insertion of a new sample before a measurement is made thereon, in order that all vestiges of air and moisture which enter the counter during the sample replacement operation be known to be removed. As is well known, traces of air or moisture in the ionizing region will seriously affect the operation of the counter, particularly in the Geiger region, and may even produce a condition of continuous discharge.

Additionally, none of the flow counters of the prior art are fully suitable for the counting of highly volatile samples, since the vapors of the samples themselves become contaminants of the ionizing gas, and thus render the measurements inaccurate.

Thus the flow counters of the prior art, although capable of sensitive and accurate measurements, nevertheless are subject to a number of difficulties, particularly where the matter of reduction of cost is important. Unless complicated gas locks are employed, the amount of air taken into the counter body during each replacement of a sample is relatively high, and the amount of time required for flushing of the air so entering which must expire before a measurement can be made is excessive. The employment of a gas lock for the introduction of samples reduces this flushing time, but only at considerable expense, and additionally introduces difficulties of keeping the device clean and uncontaminated. Furthermore the flow counters made prior to the present invention cannot in general be employed for measurements on volatile samples.

Underlying the present invention is the discovery that the difficulties as mentioned above experienced with the prior art flow counters arise primarily from inefficiency in the manner in which the flowing gas is introduced into the body or cavity of the counter. It has been discovered that the jets and orifices employed in the past for this purpose are relatively inefficient in sweeping the gas through the counter, and thus in removing air introduced during sample changing, air introduced by leakage, and vapors from a volatile sample. It is the essence of the present invention to provide in such counter a gas inlet structure which provides a much more efficient sweeping of the gas within the counter volume, and thus greatly reduces the time which must elapse before taking of a measurement on a newly inserted sample. At the same time, the invention permits construction of counters of a lower cost than those previously employed for the purpose, since the improved efficiency of sweeping produced by the present invention permits less precaution as to counter leakage after sample insertion than was heretofore required. Additionally, the present invention affords flow counters in which volatile samples may be measured without elaborate precautions concerning the presence of the sample vapor in the counter.

In the structure of the present invention, the gas, rather than being introduced through a single inlet as in the commonly known prior art counters, is introduced through a foraminous plate or wall, and preferably through apertures distributed with substantial uniformity

over the entire cross-sectional area of the cavity. In the most efficient systems of the invention, the gas is introduced through a porous plug which forms an end wall of the cavity. The invention is of advantage in flow counters both of the type employing a gas lock mechanism and in those in which no such lock is employed. However, it is particularly adapted to the latter type, since the efficiency and speed with which the present structure produces flushing of residual air and other impurities from the counter volume, particularly from the high potential gradient region adjacent to the anode wire, after insertion of a sample are so high as to render unnecessary elaborate devices to reduce the amount of air entering the counter volume during sample insertion. Accordingly, in the appended description of specific embodiments of the invention, illustrated in the attached drawing, the counters described are of a type having no special gas lock apparatus for introduction of samples.

For complete understanding of the invention, reference is made to the embodiments illustrated in the drawing, in which:

Fig. 1 is a vertical sectional view of a nuclear radiation counter embodying the teachings of the invention;

Fig. 2 is a horizontal sectional view of the counter of Fig. 1 taken along the line 2—2 in the direction indicated by arrows;

Fig. 3 is a vertical sectional view of another counter embodying the invention;

Fig. 4 is a top plan view of an aperture or orifice plate which may be substituted for a porous plug constituting a part of the device of Fig. 1 in another embodiment of the invention;

Fig. 5 is a schematic diagram illustrating electrical and gas flow connections suitable for a counter embodying the invention.

Referring first to Figs. 1 and 2, the embodiment therein illustrated comprises a short circular stainless steel tube or cylinder 10, which defines the counter volume or enclosure. The bottom edge of the tube 10 rests in a rabbet 12 in the inner top surface of an annular ring 14, of brass. Secured to the top edge of the tube 10, as by brazing, in a stainless ring 16 in which is sealed a porous plug or disc 18. The plug 18 may be, for example, of porous sintered stainless steel, such as that which is sold by Micro-Metallic Corporation. Atop the ring 16 is an annular fiber gasket or washer 20. Resting on the washer 20 is a brass lid or top plate 22, central of which is a nipple 24 adapted to receive the end of a gas feed line. The bottom ring 14 has a pair of circumferentially opposed countersunk apertures 26, and the upper plate 22 has corresponding tapped apertures 28, and screws 30 hold the assembly together as a unit. Mounted through an aperture 32 in the wall of the tube 10 is a glass insulating tube 34 secured by wax or cement 36. Sealed in the inner end of the insulating tube 34, and supported thereby in a horizontal plane is a wire anode loop 38, which may be, for example, of two mil stainless steel.

The assembly thus described rests on a flat metal plate 40, to which is secured a terminal post 42 serving as a connector for the cathode lead wire 44. The tube 10, which serves as the cathode of the counter, is electrically connected to the cathode lead wire 44 during a counting operation by the annular ring 14. A sample is introduced into the counter by merely lifting the assembly from the plate and replacing it after placing the sample on the plate.

The region between the upper plate 22 and the porous plug 18 serves as a pressure chamber or gas inlet header 46. It will be seen that gas introduced under pressure into the chamber 46 by means of the nipple 24 will flow through the pores of the plug 18 with uniform distribution across the cross-sectional area of the tube 10 and will flow downward in a manner similar to the motion of a piston, with a minimum of turbulence, eddying and other disturbance of uniform flow, and with substantially uniform exposure of the various portions of the anode loop to the flushing action of the gas, all portions of the anode loop being disposed substantially crosswise to the direct flow path between the gas inlet and outlet. With the structure illustrated, it is found that without special precaution as to intake of air when the assembly is lifted from the plate 40 for replacement of the sample (a sample plate or holder being illustrated in dotted form at 48), the volume of the counter may nevertheless be completely flushed of all air and ready for the counting operation within a fraction of a minute, whereas a time of the order of minutes is required where the gas is introduced into the counter through a jet or orifice which is not so directed as to produce direct gas flow crosswise of the entire length of the anode. No greasing or precision grinding or other sealing of the interface between the ring 14 and the plate 40 is required with the present structure, since the circularly dispersed leakage which will exist at this interface will of necessity be outward rather than inward. It is found that in the flow counters of the prior art which do not employ the relation between the gas inlet structure and the anode wire of the present invention, if no attempt whatever is made at establishing a seal on any region of the interface between the sample support plate and the counter body, the variations of gas velocity in the various regions within the counter body may actually serve to draw atmospheric air into the counter at one part of the interface while expelling it at another part of the interface and permit such atmospheric air to remain in the region of the anode wire. Such effects are effectively prevented by the structure illustrated.

In Fig. 4 is shown a simpler and less expensive, and only somewhat less efficient, construction for the foraminous wall which is formed by the porous plug 18 in the embodiment of Fig. 1. The device of Fig. 4 is a perforated plate 50 of stainless steel, which may be substituted readily in the device of Fig. 1 for the plug 18 and ring 16. Apertures 52 in the plate 50 are equally spaced and symmetrically disposed with respect to the axis of the counter. The employment of a plate such as that of Fig. 4 as the foraminous wall admitting the inlet gas to the counter volume reduces the expense of constructing such a counter, but the employment of a porous plug is preferable from the standpoint of efficiency of performance, since the porous plug structure produces a maximum of uniformity of gas flow over the cross-sectional area of the counter cavity, and minimizes the jets and eddies which have been found to produce the limitations on prior flow counters discussed above.

In Fig. 3 is shown another structure wherein a novel gas inlet system is applied to a glass-body counter. The counter illustrated consists generally of a glass tube 54, a vertical center wire 56 having a bead 58 at the lower end thereof, and a metallic cathode 60, which is connected to the exterior by a wire 62 extending out through the envelope or tube 54. A nipple 64 is provided for the admission of counter gas. The counter as thus far described is similar to a type heretofore employed as a flow counter. However, there is herein added, extending across the upper portion of the counter, a foraminous wall, which in this case consists of a fritted glass filter 66 of a maximum pore size of 5 microns, such as that designated as "fine," commercially available under the name "Pyrex." The porous plug 66 thus constructed is sealed at 68 to the glass counter body, and also is sealed to a glass bead 70 through which the center wire 56 extends through the center of the plug 66, thus forming a pressure chamber or header 72 in the upper part of the counter.

As is obvious to persons skilled in the art, the sizes of the ports in the plugs 18 and 66 or of the apertures 52

in the plate 50 are selected to be sufficiently large to permit the flowing of the quantities of gas required for proper flushing with reasonable pressure in the chamber or header, but sufficiently small to assure that the gas flowing from the chamber or header is equally distributed in flowing through the pores or apertures.

The embodiment of Fig. 3, like the embodiment of Fig. 1, is designed for use with a table or other support similar to the plate 40, the outflow of gas from the counter being through the circular leakage path which exists between the counter body and the table. However, it is found that the gas flow system of the counters of the invention is so efficient in sweeping out the counter volume that a counter such as those illustrated can, when employed with a gas which is lighter than air, be employed without the use of a base plate. The counter may be made to perform satisfactorily by merely holding it in a suitable support and bringing samples to be counted up to the downwardly disposed mouth of the counter body. Among the gases suitable for this purpose are the lighter-than-air gases described in United States Patent No. 2,519,864, issued August 22, 1950 to Paul B. Weiss.

In Fig. 5 is shown schematically the manner in which the counter, generally indicated by the numeral 74, is connected electrically and in the gas flow system. As shown in Fig. 5, the counter of the invention (which may be, among others, a counter described above) is provided with a gas inlet 76, corresponding to the nipple 24 or 64 of the embodiments described above. As shown in this figure, the foraminous wall 78 admits gas uniformly to the region between the schematically indicated anode 80 and cathode 82, and the gas leaves the counter body through an outlet opening 84, which may be leakage at a joint, as described above, or may, in some embodiments, be an aperture or series of apertures especially provided for this purpose. As is conventional in flow counters, the gas is supplied from a source 86 through a device 88 for roughly observing the flow rate, such as a bubbler. The gas may of course be any gas suitable for the counting of nuclear radiations at approximately atmospheric pressure. The electrical connections are the same as in a conventional Geiger or proportional counter, the electrodes being connected in series with a resistance 90 and high voltage supply 92, the output voltage pulses being coupled by a condenser 94 to a suitable amplifier and counting apparatus 96.

As pointed out above, the embodiments of the invention illustrated in the drawing and described herein in accordance with the requirements of the patent laws are merely illustrative of the invention, which is obviously not limited to the particular embodiments shown and described.

What is claimed is:

1. A flow-type Geiger counter comprising a thin wire loop anode electrode and a cathode electrode coaxially surrounding the anode loop to form an ionization region therebetween, constructed and arranged for the production of Geiger pulses in response to incident radiations, a circular foraminous gas inlet to the ionization region, and a circular gas outlet from the ionization region facing and opposed to the inlet, the various portions of the anode loop being in the direct path between the inlet and the outlet whereby a gas introduced through the inlet flows directly across all longitudinal portions of the anode loop.

2. A flow-type Geiger counter comprising a thin wire loop anode electrode and a cathode electrode coaxially surrounding the anode to form an ionization region therebetween, constructed and arranged for the production of Geiger pulses in response to incident radiations, a plurality of gas inlet apertures to the ionization region, and a gas outlet from the ionization region facing and opposed to the inlet apertures, the various portions of the anode loop being in direct paths between the inlet apertures and the outlet whereby a gas enters the counter in a plurality of streams and flows substantially directly across all portions of the loop to the outlet with a minimum of turbulence.

3. A flow-type Geiger counter comprising a tubular cathode, an anode within the cathode comprising a loop of thin wire in a plane transverse to the axis of the cathode, a gas inlet at one end of the cathode comprising a plurality of gas inlet apertures dispersed symmetrically with respect to the axis of the cathode, and a gas outlet coaxial with the cathode at the opposite end of the cathode, substantially all portions of the anode being in the direct path of the gas between the inlet and the outlet to produce efficient sweeping of the gas in the immediate region of all portions of the anode wire.

4. A flow-type Geiger counter comprising a circular cathode, an anode within the cathode comprising a loop of thin wire surrounding the axis of the cathode, a gas inlet to the ionization region defined by the anode and the cathode comprising a plurality of gas inlet apertures dispersed symmetrically with respect to the axis of the cathode, and a gas outlet from the ionization region coaxial with the cathode, substantially all portions of the anode being in the direct path of the gas between the inlet and the outlet to produce efficient sweeping of the gas in the immediate region of all portions of the anode wire.

5. A flow-type Geiger counter comprising a plurality of electrodes including a thin wire anode and a cathode constructed and arranged for the production of Geiger pulses in an ionizable gas in the ionization region between the electrodes in response to incident radiations, and a gas inlet to, and a gas outlet from, the ionization region, the gas inlet comprising a plurality of apertures on the opposite side of the ionization region from, facing, and dispersed symmetrically with respect to, the gas outlet and adapted to produce a flow of gas toward the anode and the outlet, all portions of the anode wire being in the direct flow path between inlet and outlet and disposed substantially crosswise of the gas flow to produce efficient sweeping of the gas in the immediate region of all portions of the anode wire.

6. A flow-type Geiger counter comprising an enclosure having an opening adapted for the placing of a sample-holder therein and having a plurality of electrodes including a thin wire anode and a cathode constructed and arranged for the production of Geiger pulses in an ionizable gas in the ionization region between the electrodes in response to incident radiations, and a gas inlet to the enclosure for flowing such ionizable gas through the ionization region and out of the opening, the gas inlet including a plurality of apertures on the opposite side of the ionization region from, facing, and dispersed symmetrically with respect to, the opening, all portions of the anode wire being in the direct flow path between inlet and outlet and disposed substantially crosswise of the gas flow to produce efficient sweeping of the gas in the immediate region of all portions of the anode wire.

7. A flow-type radiation counter comprising a circular cathode enclosure having a mouth adapted to be placed over a radioactive sample and having a loop anode wire in a plane transverse to the axis of the cathode constructed and arranged for the production of ion-multiplication pulses in an ionizable gas in the ionization region between the electrodes in response to incident radiations, and a gas inlet to the enclosure including a plurality of apertures dispersed in a circular pattern concentric with the cathode and facing the mouth with the various portions of the anode wire interposed between respective apertures and the mouth to direct the flow of gas over all portions of the anode wire to produce efficient sweeping of the gas in the immediate region of all such portions.

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