United States Patent [19]

Atac

[11] **3,787,746**

[45] **Jan. 22, 1974**

[54] **QUENCHING GAS FOR DETECTORS OF CHARGED PARTICLES**

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

[22] Filed: **May 11, 1973**

[21] Appl. No.: **359,396**

[52] **U.S. Cl.**..... **313/93,** 250/374, 313/223

[51] **Int. Cl.**..... **H01j 39/26**

[58] **Field of Search**..... 250/374, 375; 313/93, 223, 313/224

[56] **References Cited**

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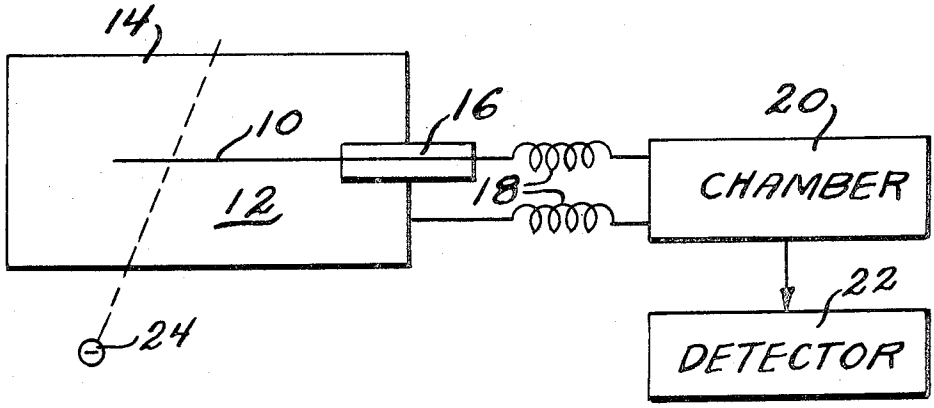
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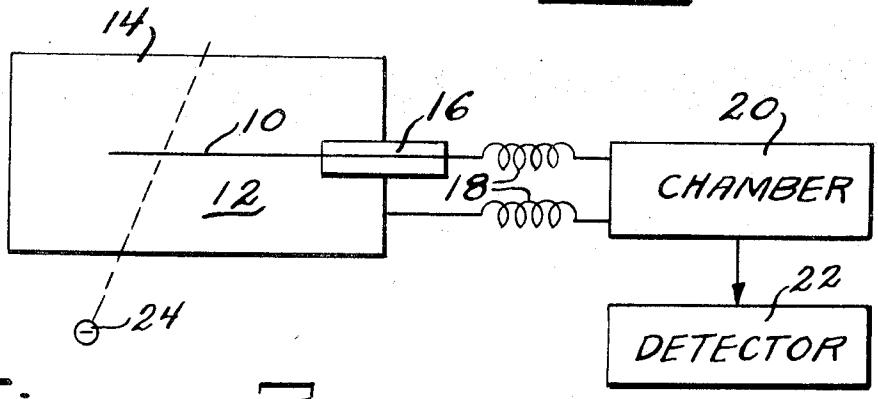
[57] **ABSTRACT**

Operation of detectors of charged particles such as wire counters and Geiger-Muller tubes is improved by filling the counters with a quenching-gas mixture of argon, isobutane and methylchloroform.

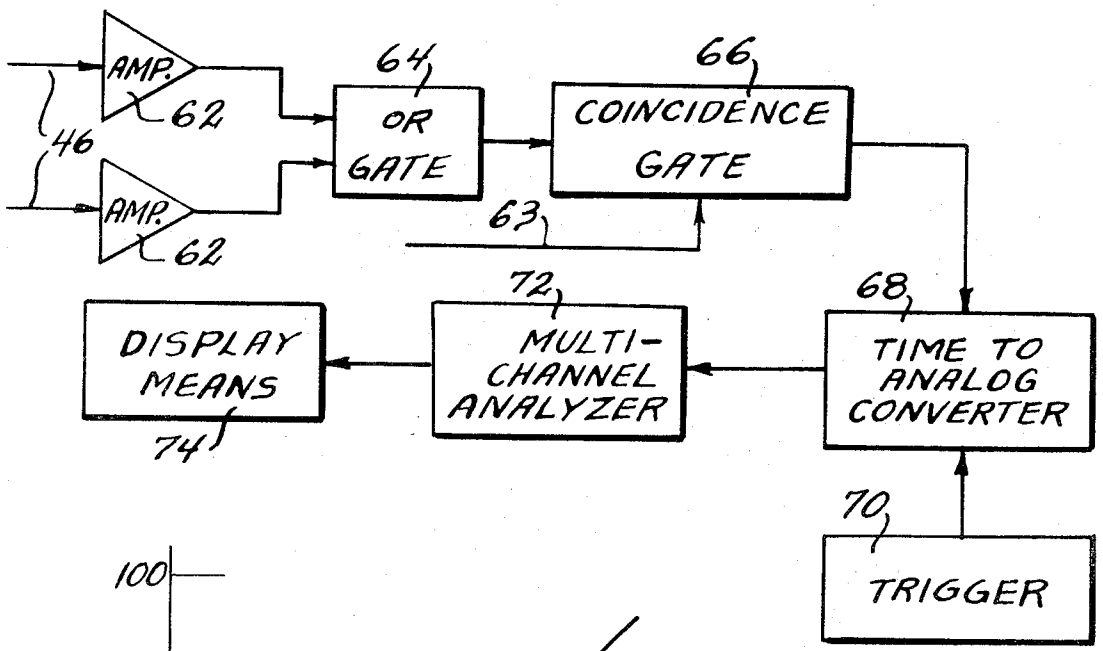
7 Claims, 7 Drawing Figures



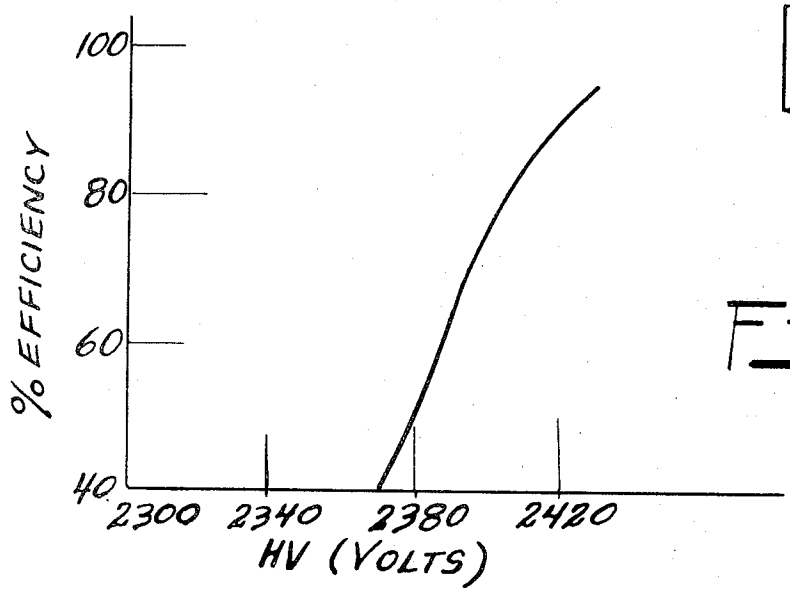
Fig—1



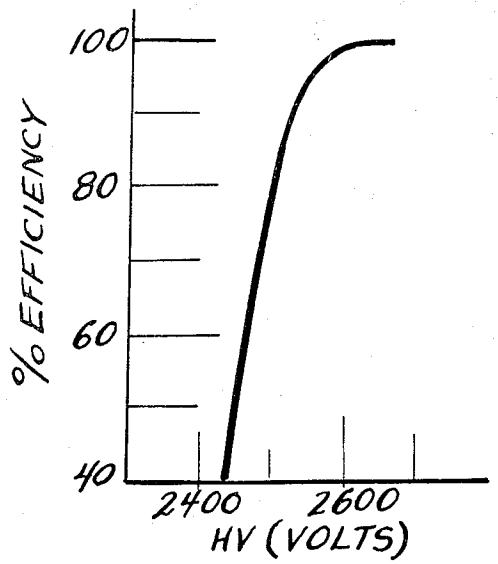
Fig—2



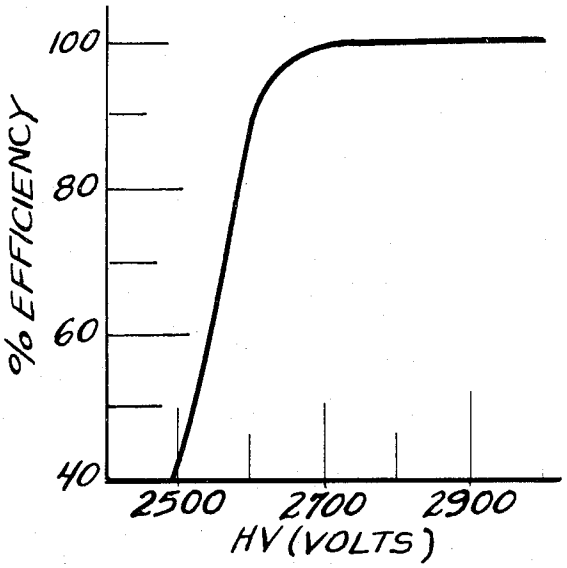
Fig—3



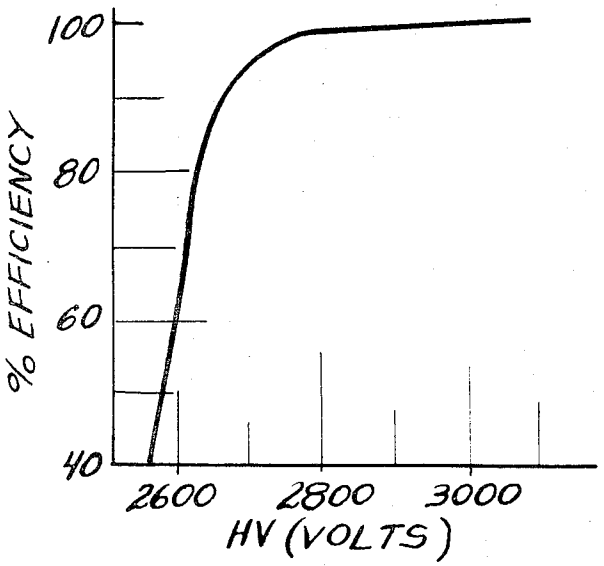
Fig—4



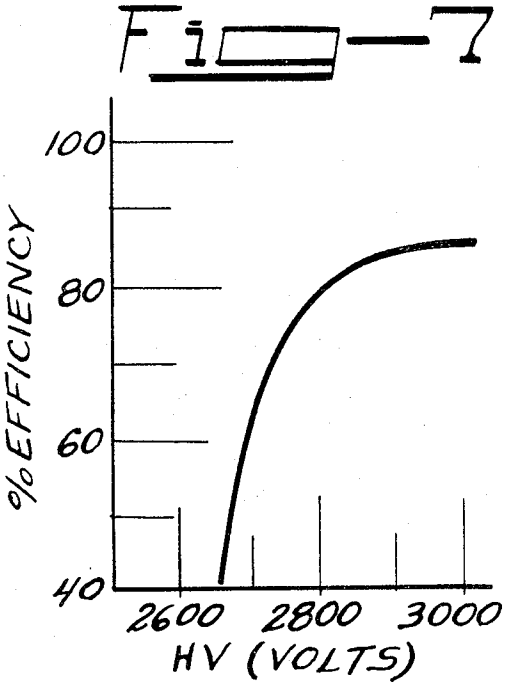
Fig—5



Fig—6



Fig—7



QUENCHING GAS FOR DETECTORS OF CHARGED PARTICLES

CONTRACTUAL ORIGIN OF THE INVENTION

The invention described herein was made in the course of, or under, a contract with the United States Atomic Energy Commission.

BACKGROUND OF THE INVENTION

This invention relates generally to detectors of charged particles of the type in which passage of a charged particle produces ionization in a gaseous medium, which ionization triggers an electrical discharge. Monitoring of the electrical discharge then provides information about the passage of the charged particles. In particular, it relates to a quenching gas for use in the gaseous medium.

There are various types of detectors of the passage or presence of charged particles in which an electrical discharge is initiated by the ionization resulting from passage of the charged particles. Such detectors include wire counters and Geiger-Muller counters. Each such device comprises a discharge region through which the charged particle passes and a plurality of electrical conductors located in the discharge region and between pairs of which an electrical potential difference is maintained. The electrical potential difference or voltage is normally set to a value close to but under the value necessary to initiate a discharge between the conductors. The ionization resulting from passage of a charged particle is enough to initiate an electrical discharge between two conductors. Electrical circuitry connected to the conductors can then provide identifying information about the passage of the charged particles.

For such a device to be useful, it is necessary to clear the leftover ions following a discharge since a continuing discharge would not provide later information about the passage of other particles. Accordingly, such devices are reset or readied for reuse by means such as using quenching gas with the ionizing gas mixture. This may be combined with means such as reducing the voltage applied between discharge conductors with a pulse or with design of the internal impedance of the electrical source.

A particular problem of counters using ionization as a triggering means is the time needed to reset to prepare for the next count. Attention has been devoted to electronic means for restoring such counters to a ready state. Various combinations of gases such as argon with heptane, methane, n-pentane or alcohol have also been used to accomplish more effective quenching. The utility of such devices in measuring rapidly rising pulses and in resolving closely spaced pulses is a direct function of the ability to reset the counter and thus place it in readiness to receive and respond to the next entering particle. However, when the voltage between the electrodes is raised to improve pulse and time resolution, the above quenching gases have little or no effect.

It is also necessary in applications involving a plurality of detecting regions to locate the presence of a charged particle with a desired degree of precision. As the desired precision increases, the designer uses more wires, finer wires, and more closely spaced wires in wire counters and counting chambers. Quenching a discharge that has been initiated is important here for the additional reason that fine wires are more readily damaged by sustained arcs.

Other considerations of concern in particle detectors of the type described include the gas multiplication factor and the detection efficiency. The gas multiplication factor is a term applied to describe the apparent charge amplification of the counter. This measures the degree of avalanching in the discharge, and is a count of the number of charged particles in a typical discharge produced in response to a single triggering particle. In a given counter, the higher the multiplication factor, the closer the counter comes to the edge of stability. A related measure of the effectiveness of a counter is the detection efficiency, which describes the percentage of particles passing through the detector that produce a detection pulse. An ideal detector has a high multiplication factor, of the order of 1 million, with a detection efficiency approaching 100 percent. The ideal detector also has a high time resolution which means that time between the passage of the particle and the production of a detectable pulse in the counter is very short. It is evident that the requirements on such counters are inconsistent in the high multiplication factors and high detection efficiencies require operation of such counters near the points at which they will break down and sustain a continuing discharge. This, of course, represents undesirable operation.

It is an object of the present invention to provide an improved gas mixture for a detector of charged particles.

It is a further object of the present invention to provide a new gas mixture for ionizing counters.

It is a further object of the present invention to provide a new quenching gas for use in ionizing counters.

It is a further object of the present invention to provide a gas mixture for a detector of charged particles which has improved gas multiplication, detection efficiency and time resolution.

SUMMARY OF THE INVENTION

Particle detectors of the type that produce a pulse of current in response to the passage of a charged particle are improved in operation by filling the discharge space with a gas mixture comprising argon, isobutane, and trichloroethane.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view of a detector of charged particles using the gas mixture of this invention;

FIG. 2 is a block diagram of an electronic circuit for processing signals from a detector of charged particles;

FIG. 3 is a plot of detection efficiency vs voltage for an argon-methane gas mixture;

FIG. 4 is a plot of detection efficiency vs voltage for an argon-isobutane gas mixture; and

FIGS. 5 to 7 are plots of detection efficiency vs voltage for argon-isobutane-trichloroethane gas mixtures.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 is a view of a detector of charged particles in which the gas mixture of this invention can be used. In FIG. 1, wire 10 is in a gas-tight chamber 12 which is formed by enclosing conductor 14. Feedthrough 16 is

an electrical insulator which permits wire **10** to leave chamber **12** without making electrical contact with conductor **14.** The electrical leads **18** connect both wire **10** and conductor **14** to electrical supply **20.** Electrical supply **20** maintains a desired level of operating voltage between wire **10** and conductor **14** through leads **18** and also provides an indication, that is detected by detector **22,** whenever a charged particle **24** passes through chamber **12** producing ionization and a resultant pulse of electrical conduction between wire **10** and enclosing conductor **14.** An ionizing gas comprising a mixture of argon, isobutane and trichloroethane is disposed in chamber **12** to quench sparks or discharges initiated by the passage of charged particle **24** through chamber **12.** The combination of wire **10,** chamber **12,** conductor **14** and feedthrough **16** may comprise a Geiger-Muller tube or may comprise a portion including one of a plurality of wires **10** in a wire counter.

Signals produced by a detector of charged particles can be processed in the circuit of FIG. **2.** In FIG. **2,** a plurality of leads **46** transmit signals from the detector to a plurality of amplifiers **62.** The outputs of amplifiers **62** are connected to multiple input OR gate **64,** the output of which is connected to coincidence gate **66** and thence to time-to-amplitude converter **68.** A timing signal from another detector or timing circuit can be applied to coincidence gate **66** via line **63.** Converter **68** is triggered to begin counting by an external trigger **70** and counts for a predetermined period of time to generate an output signal that is proportional in amplitude to the width of the pulse received from coincidence gate **66.** The output signal from converter **68** is connected to multichannel analyzer **72** which provides a spectrum of pulse count versus energy on display means **74.**

An apparatus according to the principles of the present invention has been built and operated to produce detected high-energy pulses. The sensitive area of the detector as seen by the beam was 80 cm^2. The spacing between wires was 1 millimeter. The wires were 10 micrometers diameter tungsten which was electropolished and plated with gold. The counter as built comprised **124** wires parallel to one another and secured in place in epoxy material on an epoxy-glass frame. Only the middle **64** of the wires were used for detecting purposes, the other **60** being maintained at the same potential as the conducting plates. The conducting plates themselves comprised aluminum foil 25 micrometers in thickness. A gap of 2 millimeters was maintained between the plane of the wires and each of the aluminum foil electrodes. The detector can provide gas multiplication factors between 10^5 and 10^7 without going into spark formation or breakdown. The detection efficiency approaches 100% with large high-voltage plateaus. A time resolution of ±6 nsec at FWHM from pulses with use times between 6–10 nsec has been obtained. The gas mixture was prepared by bubbling an argon-isobutane mixture through liquid trichloroethane at 0° C. The concentration of trichloroethane was varied by varying the percentage of the argon-isobutane mixture that was bubbled through the liquid trichloroethane.

In both wire counters and Geiger-Muller counters it is desirable to have a plateau on the detection efficiency curve and to have the plateau at as high a voltage and efficiency as possible. The higher operating voltages result in improved pulse height and time resolution. A wide plateau is desirable to permit more stable operation.

FIG. **3** shows a detector efficiency vs voltage curve wherein the gas mixture is 90% argon and 10% methane. Above 2,450 volts the quenching is not sufficient; therefore the counter goes into breakdown. In FIG. **4** the gas mixture is 80% argon and 20% isobutane. There is a very narrow plateau (approximately 50 volts) but the counter is unstable beyond 2,700 volts.

FIG. **5** is a plot of the percent detection efficiency versus applied voltage for a counter in which the gas mixture comprises 80% argon, 20% isobutane of which 20% of this mixture has been bubbled through liquid methylchloroform (1,1,1-trichloroethane) at a temperature of 0° C. This results in the addition of a volume percentage of 0.25% of methylchloroform to the gas mixture. In FIG. **5** the curve exhibits low values of efficiency for lower values of applied voltage and rises to a plateau approaching the upper limit of voltage for stable operation. The plateau of this curve is approximately 300 volts in width. This shows an improvement in operation over the results obtained with the gas mixture of FIG. **4** which contained no methylchloroform.

A further improvement in operation is indicated in FIG. **6** which is a plot of the percent detection efficiency versus applied voltage for a counter of the type described herein in which a gas mixture of 80% argon and 20% isobutane has 35% of its volume bubbled through liquid methylchloroform at 0° C. This produces a concentration of methylchloroform in the mixture of 0.37% by volume. In FIG. **6** the curve begins at a low value of efficiency for lower values of voltage and rises to a plateau. The plateau of this curve has a width of 400 volts. This combination of gases produced the best combination of broad plateau and high efficiency. The results of a further increase in the concentration of methylchloroform are shown in FIG. **7** which is a plot of the percent efficiency versus applied voltage of a counter of the type described herein in which the primary gas mixture is 80% argon and 20% isobutane. Fifty percent of this gas was bubbled through methylchloroform at 0° C. to produce a volume concentration in the final mixture of 0.65% methylchloroform. In FIG. **7** the curve begins at a low level of efficiency for lower voltages and increases to produce a plateau for higher voltages. However, the percent efficiencies associated with the plateau are noticeably lower than those associated with the plateaus of the earlier curves.

It can be seen from a comparison of these figures that the addition of methylchloroform in small amounts to the mixture of 80% argon and 20% isobutane has provided an increase in the width of the plateau in the efficiency curve. Breakdown, spark formation and spurious counts due to the field emission are greatly reduced or eliminated with the addition of methylchloroform. The mixture using 0.65% of methylchloroform produces operation that is improved over that attained with no methylchloroform but has the effect of reducing the percent efficiency of the detection plateau.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In a detector of charged particles having electrodes with an electric field therebetween and an ionizing gas in the electric field and wherein passage of a

charged particle through the gas acts to ionize the gas to develop an electrical spark between the electrodes, the improvement wherein, the gas is a mixture of argon, isobutane (2-methylpropane) and trichloroethane.

2. The detector of claim **1** wherein, said trichloroethane is methylchloroform (1,1,1-trichloroethane).

3. The detector of claim **2** wherein, said gas mixture is from 50% to 85% argon, from 50% to 15% isobutane and up to 0.65% methylchloroform.

4. The detector of claim **3** wherein, said gas mixture contains from 0.25% to 0.65% methylchloroform.

5. The detector of claim **4** wherein, said gas mixture contains substantially 0.37% methylchloroform.

6. The detector of claim **2** wherein, said gas is 80% argon and 20% isobutane to which has been added 0.25% to 0.65% methylchloroform.

7. The detector of claim **6** wherein, said gas contains substantially 0.37% methylchloroform.

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