United States Patent

[11] 3,622,787

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[33] **Netherlands**
[31] **6807625**

[54] **DEVICE FOR MAKING VISIBLE AND/OR REGISTERING γ-QUANTA DENSITIES OR TWO-DIMENSIONAL β-PARTICLE DENSITY DISTRIBUTIONS**
1 Claim, 6 Drawing Figs.

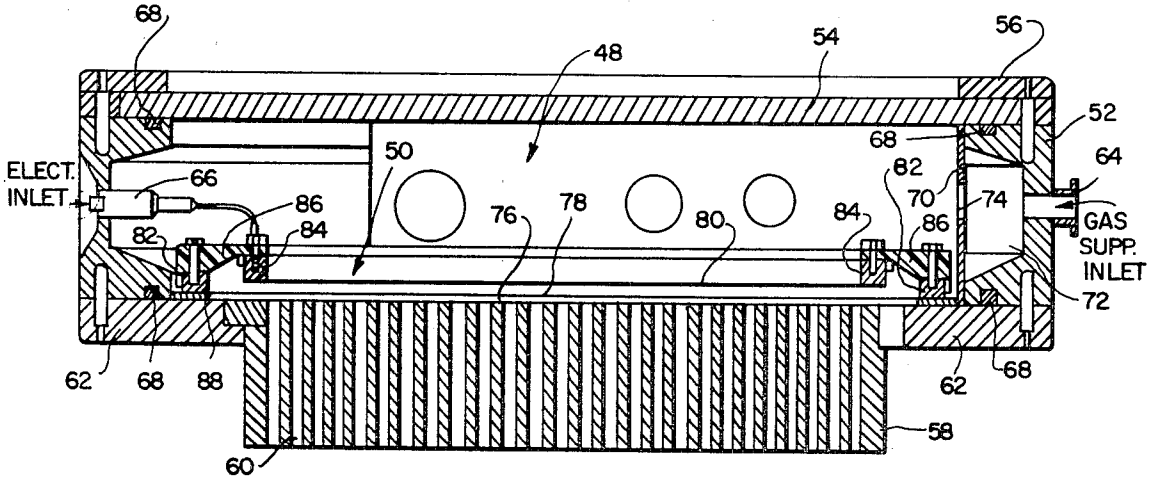
[52] U.S. Cl. **250/83.3,** 250/83.6
[51] **Int. Cl.** **G01t 1/16**
[50] **Field of Search** 250/83, 83.6, 83.3

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ABSTRACT: A device for making visible and/or registering the flux density of gamma-quanta or the two-dimensional density distribution of beta-particles includes a gas and vapor-filled spark discharge chamber with a flat cathode, a flat, grid-form anode and a grid-form auxiliary electrode arranged therein. The cathode is positioned parallel to and spaced from the anode and the auxiliary electrode is located therebetween. A high-voltage source is connected to the electrodes and an integrating recorder registers the pattern of the spark discharges between the auxiliary electrode and the anode such as caused by entering radiation. The auxiliary electrode is galvanically connected to the cathode and is spaced therefrom a distance such that the electron cloud which triggers the spark discharge is not attenuated by electron attachment in the space between cathode and auxiliary electrode.



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SHEET 1 OF 2

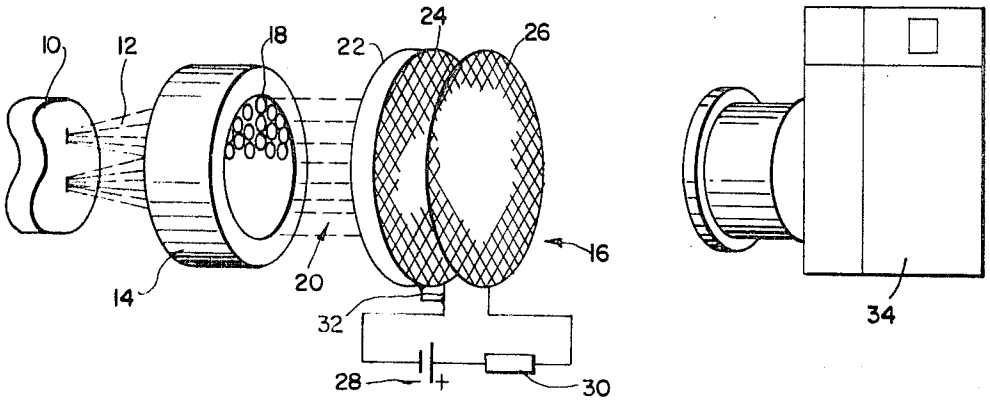


FIG. 1

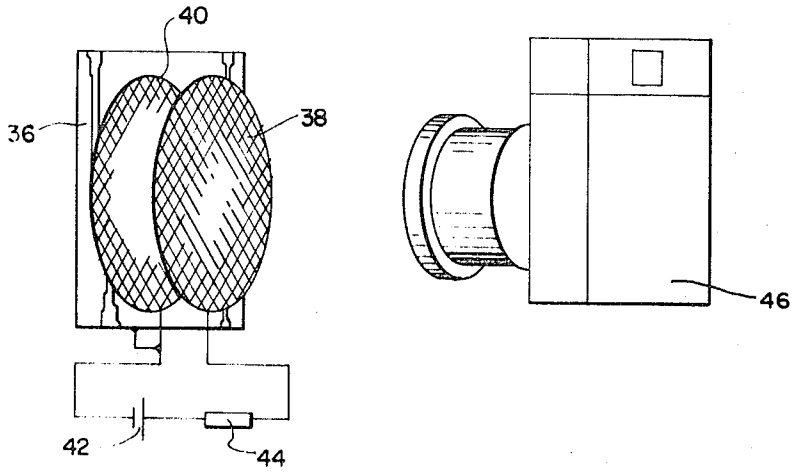


FIG. 2

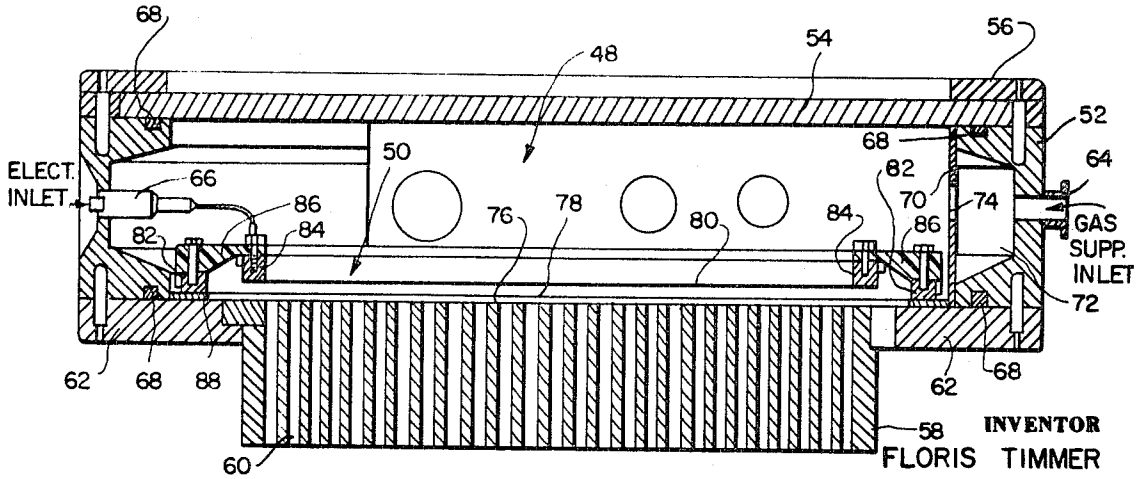


FIG. 3

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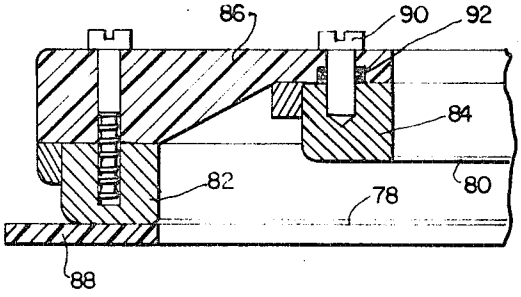


FIG. 4

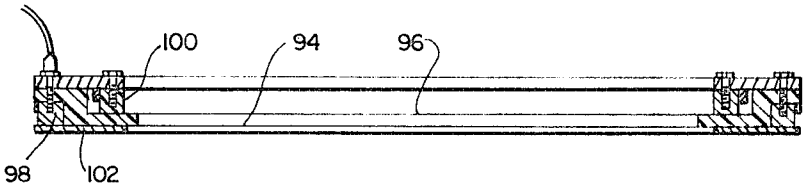


FIG. 5

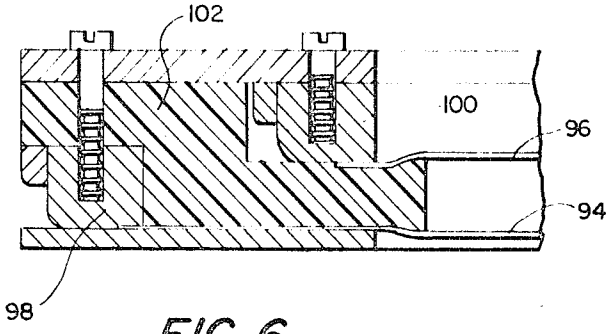


FIG. 6

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DEVICE FOR MAKING VISIBLE AND/OR REGISTERING γ-QUANTA DENSITIES OR TWO-DIMENSIONAL β-PARTICLE DENSITY DISTRIBUTIONS

FIELD OF THE INVENTION

The present invention relates to a device for making visible and/or registering the flux density of gamma-quanta or the two-dimensional density distributions of beta-particles and more particularly to devices of the type described used in radio diagnostics and radio chromatography.

BACKGROUND OF THE INVENTION

A known device for performing the functions described, that is, making visible and/or registering the flux density of gamma-quanta or the two-dimensional density distributions of beta-particles generally comprises a gas and vapor-filled spark discharge chamber including a cathode, an anode, and an auxiliary electrode positioned between the cathode and anode.

In this known device gamma rays are converted into primary electrons in the cathode and in the gas layer between the cathode and the auxiliary grid.

The secondary electrons released by those primary electrons are, however, strongly attached by the gasfilling. When the cloud of the secondary electrons which enter the spark gap is too small no spark can be triggered.

The transition to this space is promoted by bringing the cathode on a negative potential with respect to the auxiliary electrode.

The above described construction of the electrode system and the associated working principle of the known device have various disadvantages.

In the first place the contribution by the cathode to this detection process is negligible in this configuration. Therefore, an expensive xenon gasfilling has been provided to improve the poor efficiency of the argon gasfilling.

Moreover, as a result of the small conversion efficiency of the gas filling, the number of spark discharges per time-unit will be small during operation, which means that the formation of a detailed picture of the radiation source will require a very long measuring time which, especially when examining patients, is always undesirable and in certain cases even impossible.

Another important objection of the known device is that, as a result of the rather long distance between the cathode and the auxiliary electrode and thus between the cathode and the anode, there will occur such a spreading of secondary electrons that in the plane of the anode where those give rise to visible sparks a blurred picture is formed of the radiation source which is being investigated.

The known device has the further disadvantage that in the transormation of the gamma-quanta into electrons, Compton scattering will occur much earlier in the gas than in the cathode. Therefore, this device is limited with respect to the maximum energy of the gamma-quanta to be observed. The picture will be greatly blurred by this Compton scattering.

SUMMARY OF THE INVENTION

The invention now being registered provides a device of the above mentioned type in which these disadvantages are avoided, because in it the auxiliary electrode is placed at such a short distance that the secondary electron attachment and dispersion are negligible, while further the auxiliary electrode is connected galvanically with the cathode.

This electrode configuration has further the advantage that the material for the auxiliary grid can be chosen as resistive as possible for the spark discharges and that the material of the cathode can be optimized for the conversion of gamma-quanta into primary electrons. Even not deposition of waste products of the quenchgas on the auxiliary grid will disturb the cathode performance.

In the new device according to this invention the number of spark discharges per time-unit in the space between the auxiliary electrode and the anode is almost entirely determined by the number per time-unit of primary electrons leaving the cathode. Since this last number is considerably larger than the number of primary electrons derived by the ionization of the gas filling, the time in which with this new device, a detailed picture is obtained of the radiation source being investigated is considerably shorter and certainly very much shorter than with an apparatus working according to the ionization principle.

The short distance, used in the device according to the invention, between the auxiliary electrode and the cathode has the further advantage that the anode can also be placed closer to the cathode, making it possible thus to greatly increase the definition of the image of the radiation source.

A further advantageous effect produced by the close spacing of the auxiliary electrode and the cathode is that the effect of Compton scattering described hereinabove is decreased because the atomic number of the cathode material can be chosen much higher than the highest possible atomic number of the gas, so that the energy range of the device is consequently increased above 140 kev. It is noted that this increase enables the use of the device with Isotope $Tc99^{M}$ which is a very important isotope used in radio diagnostics. It is noted that the energy range increase produced by the closer spacing of the electrodes permits the use of the device in reading out radio-chromatograms. Because of the energy levels of the isotopes used in these techniques, such as Carbon 14 (160 kev.) and Tritium closer 18 kev.), the range is very short, particularly for the electrons mentioned. It is thought that the fact that these electrons can be detected is due to the presence of an electric leakage field which penetrates the auxiliary electrode.

In accordance with a presently preferred embodiment of the invention a device for making visible and/or recording the flux density of gamma-quanta or the two-dimensional density distribution of beta-particles is provided which includes a spark discharge chamber filled with a mixture of gases and vapors and an electrode arrangement including a flat cathode, a flat anode constructed of gauze material and positioned parallel to and spaced from the cathode and an auxiliary electrode also constructed of gauze material and positioned between the anode and the cathode. A high voltage source is connected to the various electrodes and an integrating recorder provides an indication of the pattern of the spark discharges between the auxiliary electrode and the anode such as caused by the entry of radiation into the chamber. As discussed hereinabove the auxiliary electrode is galvanically connected to the cathode and is spaced from the cathode a distance such that the electron cloud which triggers the spark discharge is not attenuated by electron attachment in the space between cathode and auxiliary electrode. The device also includes a number of important mechanical features. These features and other features and advantages of the present invention will be set forth in or apparent from the description of the preferred embodiments of the invention found hereinbelow.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic representation of a device in accordance with the present invention used in making visible and registering the flux density of gamma-quanta;

FIG. 2 is a schematic representation of a device in accordance with the present invention used in the read out of two-dimensional radio-chromatograms;

FIG. 3 is a transverse cross-sectional view of the mechanical construction of a device in accordance with the embodiment of FIG. 1;

FIG. 4 is a detail view of a portion of the construction of FIG. 3;

FIG. 5 is a cross-sectional view of an alternate form of the electrode arrangement shown in FIG. 3; and

FIG. 6 is a detail view of a portion of the electrode arrangement of FIG. 5.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1 a schematic representation is provided of a device in accordance with the present invention, which device is generally designed for forming images of an object activated by radio isotopes such as, for example, an organ of the human body (the thyroid gland, the brain, etc.). In FIG. 1, an object charged with isotopes and generally denoted **10** emits gamma rays **12** of which a part can pass through a collimator **14** to an electrode structure generally denoted **16**. The collimator **14** is constructed of a plate of heavy material such as lead or gold and includes a large number of parallel holes **18** drilled therethrough. Holes **18** direct the gamma-rays **12** through a gas filled space generally denoted **20** to a flat cathode **22**. When the gamma-quanta produced by the interaction of the gas and the gamma-rays strike cathode **22** primary electrons are produced. These free electrons create in the absorbing process secondary electrons that move through the grid structure formed by an auxiliary electrode **24** which is constructed of gauze and is located a short distance from cathode **22**. These electrons pass to an anode **26** which is also constructed of gauze, under the influence of an electric leakage field from the spark gap. This electric field is produced by a high voltage source **28** the positive side of which is connected through a resistor **30** to anode **26** and the negative side of which is connected to cathode **22**. Auxiliary electrode **24** is galvanically connnected to cathode **22** by an electrical connection indicated at **32**. The strength of the electric field produced by source **28** is adjusted such that the cloud of electrons landing in the space between the auxiliary electrode **24** and the anode **26** will trigger a spark discharge. These discharges together will produce an image of object **10**, which image may be recorded by a camera **34**.

It is noted that the device described provides means for determining not only the form and dimensions of an object such as an organ of the human body but also provides for the observation of some of the defects in such an object such as damage caused by the presence of a "cold" tumor. Such defects may be observed in that isotopes will not penetrate those areas in which the organ is damaged and thus there is no radiation from these areas and, consequently, no spark discharges are generated.

Referring to FIG. 2, a schematic representation is provided wherein a device in accordance with the present invention is utilized in the read out of two-dimensional radio-chromatograms. In FIG. 2 a radio-chromatogram **36** and grid electrodes **38** and **40** are located in a gas-filled chamber (not shown). The chromatogram **36** contains an electron-emitting substance and thus functions in a manner similar to cathode **22** described hereinabove. The auxiliary electrode **40** is spaced a short distance from the chromatogram **36** between the chromatogram **36** and anode **38** and electrons emitted from chromatogram **36** pass therethrough to the space between the electrode **40** and the anode **38**. These electrons, under the influence of an electric field produced by a source **42** connected in series with a resistor **44**, produce spark discharges between the electrodes **38** and **40**. The pattern of the spark discharges can be recorded by a camera **46**. This pattern can also be recorded electrically by means of a digital recording circuit and where such a circuit is used the auxiliary electrode **40** is constructed of mutually parallel wires, the anode **38** is constructed of mutually parallel wires, and the auxiliary electrode **40** and the anode **38** are arranged such that the wires of the anode cross those of the auxiliary electrode.

Referring to FIG. 3, a practical mechanical embodiment of the device in accordance with FIG. 1 is shown. The apparatus of FIG. 3 includes a detection chamber denoted **48** and an electrode arrangement denoted **50** mounted within chamber **48**. Chamber **48** is formed by a cylindrical metallic housing **52** and a transparent end plate **54** which is mounted on unit **52** by a locking washer **56**. A collimator **58** including a series of holes **60** is secured to the bottom of unit **52** by a supporting ring **62**. A gas supply inlet **64** is located in the wall of unit **52** and an insulating bushing located in the wall of unit **52** provides for connection of the electrodes **50** to a suitable electrical input. The joints between the unit **52**, the end or terminal plate **54** and the supporting ring **62** are made airtight by means of O-rings **68**. Chamber **48** further includes a cylindrical gas-distribution ring **70** which is connected to inwardly projecting portions of the upper and lower sides of the wall of unit **52** so as to form a circular channel **72** between the distribution ring **70** and the wall of unit **52** which is linked with the interior of the chamber **48** by openings **74** in the distribution ring **70**.

The electrode arrangement **50** is mounted inside the gas-distribution ring **70** and comprises a flat cathode **76** which is mounted above and rests on the top side of collimator **58**, an auxiliary electrode **78** formed by a grid structure spaced from and located slightly above cathode **76**, and an anode **80** formed by a grid structure located above auxiliary electrode **78**. The cathode **76** is constructed of a material having a optimum conversion efficiency for the radiation to be detected, such as, for example, silver for the isotope I^{125} (having an energy level of 27 kev.) and gold for the isotope $Tc99^{M}$ (140 kev.). This material is preferably applied in the form of a thin layer having a thickness of 1–10 microns on a suitable substrate such as Mylar.

It is noted that in accordance with a further embodiment of the invention the efficiency of the cathode **76** may be increased by applying a cathode material galvanically to a metal support such as copper foil having a surface roughened by etching or steelraying. A cathode in accordance with such a construction will also have a rough surface which is considerably larger than the surface area of a corresponding smooth cathode of the same size and because the efficiency of the cathode is proportional to the surface area presented thereby a proportional increase in the cathode efficiency is provided.

Auxiliary electrode **78** is mounted on a thin metallic ring **82** whereas anode **80** is similarly mounted on a thin metallic ring **84**. Rings **82** and **84** are commonly supported by a supporting unit **86** which is constructed of insulating material. The shape of supporting unit **86** is such that the anode ring **84** lies with the bottom side thereof within the central opening of auxiliary electrode ring **82** in front of auxiliary electrode **78**. A thin washer **88** constructed of insulating material is positioned beneath anode ring **82** and the entire assembly is mounted on the upper side of supporting ring **62** and the cathode **76** which rests upon supporting ring **62**.

The construction of the electrode system described hereinabove enables the spacing between the various electrodes to be very precisely determined. It will be appreciated that this high precision is necessary because of the very close spacing of the cathode **76** and the auxiliary electrode **78**. Experiments with a prototype of the device illustrated wherein the spacing between the cathode **76** and the auxiliary electrode **78** is smaller than 5 mm. has indicated that the number of electrons which reach the space between the auxiliary electrode **76** and the anode **78** decreases continuously by dispersion and by attachment in the gas as this distance is increased. On the other hand there are lower limits on the spacing between the auxiliary electrode **78** and the cathode **76** in that where this distance is too small the number of secondary electrons released by the absorbing process of a primary electron originating from the cathode becomes too small to trigger the spark discharge and also photoelectric feedback in the cathode **76** may thus lead to undesired reignition phenomena. Therefore this distance should be between 0.05 mm. and 4mm.

As is illustrated in FIG. 4 the spacing between the anode **80** and the auxiliary electrode **78** may be affected by means of adjustment screws **90** and associated springs **92**. Adjustment screws **90** are used to secure anode ring **82** to supporting unit **86** and variation in the settings of these screws will produce corresponding variations in the distance between the anode **80** and the auxiliary electrode **78** so that any lack of parallelism between these elements can be corrected.

Referring to FIG. 5, an alternative construction of the electrode system 50 of FIG. 3 is shown. As perhaps can be best seen in FIG. 6, an auxiliary electrode 94 is secured to a metallic ring 98 whereas an anode 96 is secured to a metallic ring 100. Rings 98 and 100 are commonly supported by a supporting unit denoted 102 which is constructed of insulating material. Supporting unit 102 includes a small area near the central opening of the rings which gradually increases to a value which is equal to the required mutual distance between the auxiliary electrode 94 and the anode 96. The upper and lower surface of this portion of the supporting unit 102 are coated with a material of high conductivity so as to prevent the occurrence of the so-called "split effect" which can cause undesired sparks along these sides. The arrangement of FIGS. 5 and 6 provides stretching of the grid electrodes 94 and 96 such a way that they are equidistant whereby only the tolerances involved regarding the inside edge of the supporting unit play a role in determining the precision of the spacing between the planes in which the electrodes 94 and 96 are located. These tolerances can be maintained below 40 microns using conventional machines without resorting to any special techniques.

It will be appreciated that the electrode arrangements described hereinabove have the advantage that they can be readily dismantled in a simple manner for cleaning purposes and the like and can be reassembled without impairing the accuracy of the positioning of the electrodes with respect to one another.

In accordance with another feature of the invention described hereinabove a relatively inexpensive gas such as argon can be used as the filling gas for the detection chamber 48. The anode and auxiliary electrode are preferably constructed of a metal with a melting temperature of more than 2,000° C. and which has low creepage. These electrodes are preferably formed of a wolfram gauze with a wire diameter of, for example, 30 microns. It has been found that gauze electrodes of such a construction have an almost unlimited life. To prevent occurrence of corona phenomena between the auxiliary electrode and the anode which as stated, are constructed of a gauze material, these electrodes are positioned with respect to one another such that the wires making up the electrodes are nonparallel. The vapor mentioned above may be alcohol.

It is noted that where the device described hereinabove is utilized in the investigation of objects by means of radioisotopes the general construction described can be further modified by utilizing a number of cathodes supported so that selected ones of the cathodes can be moved into and out of the spark discharge chamber in accordance with the wishes of an operator.

Although the invention has been described in detail with particular reference to preferred embodiments thereof, it will be understood that variations and modifications can be effected therein within the scope and spirit of the invention as described hereinabove.

I claim:

1. A device for making visible invisible radiation, such as the flux density of gamma-quanta or the two-dimensional density distribution of beta-particles, comprising a spark discharge chamber filled with a mixture of gases and vapors, a substantially flat cathode mounted within said chamber, a flat anode constructed of a gauze material and positioned parallel to said cathode, an auxiliary electrode constructed of a gauze material and positioned between said anode and said cathode, a high voltage source connected to said cathode, to said anode and to said auxiliary electrode, and an integrating recorder for providing an indication of the pattern of the spark discharges between said auxiliary electrode and said anode caused by the entry of radiation into said chamber, said auxiliary electrode being galvanically connected to said cathode, said anode being secured to a first metal ring and said auxiliary electrode being secured to a second metal ring, said device further comprising a ringlike insulating support including a portion having opposed, substantially flat surfaces, the thickness of said portion gradually increasing in a narrow area around the central opening provided by said ringlike support, said first and second rings acting to stretch said anode and said auxiliary electrode along said opposed surfaces, respectively and a material of high conductivity located on upper and lower surfaces of said supporting unit.

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