United States Patent

[11] 3,614,443

[72] Inventors Torben Hesselbo
Welwyn Garden City;
Arthur Derek George Groves, Knebworth,
both of England
[21] Appl. No. 753,088
[22] Filed Aug. 16, 1968
[45] Patented Oct. 19, 1971
[73] Assignee Smith Kline & French Laboratories
Philadelphia, Pa.
[32] Priority Sept. 6, 1967
[33] Great Britain
[31] 40832/67

[54] **SPARK CHAMBERS**
4 Claims, 9 Drawing Figs.

[52] U.S. Cl. 250/83.6
[51] Int. Cl. G01t 1/16
[50] Field of Search .... 250/83.6, 71.5 S, 83.1, 52, 83.3 D; 313/93

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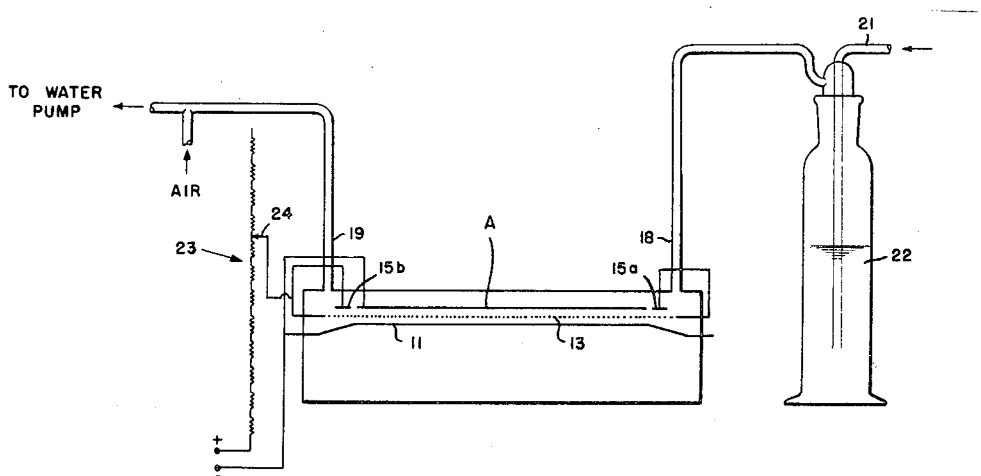
Primary Examiner—James W. Lawrence
Assistant Examiner—Davis L. Willis
Attorneys—William H. Edgerton, Richard D. Foggio, Joan S. Keps, Alan D. Lourie and Joseph A. Marlino

ABSTRACT: A gastight, crossed wire spark chamber having the major part of each of the walls thereof being formed from a transparent material and further having associated therewith manual or mechanical means for effecting movement of the chamber with respect to an externally mounted radioactive pattern in a plane substantially parallel to the planes of the electrodes disposed within the chamber.



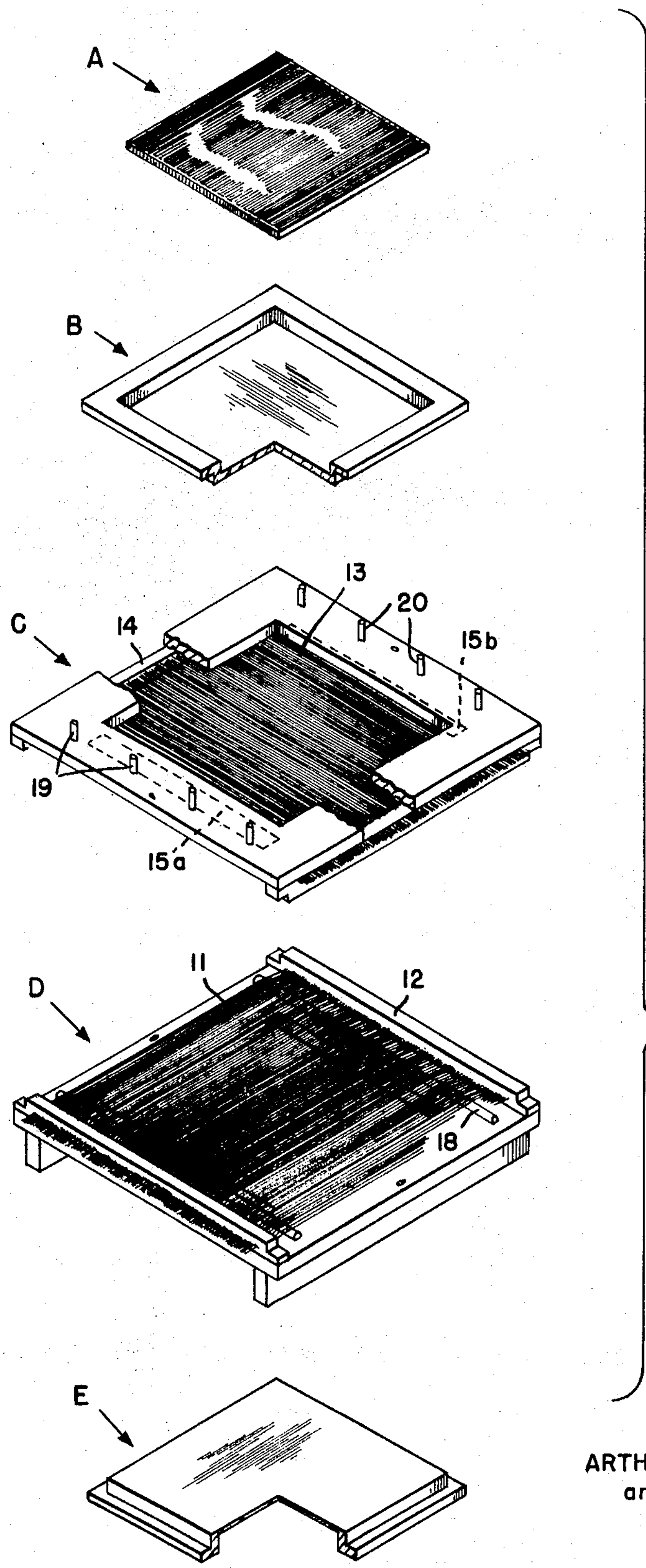


FIG. 1.

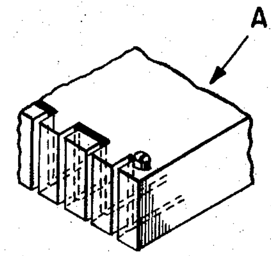


FIG. 2.

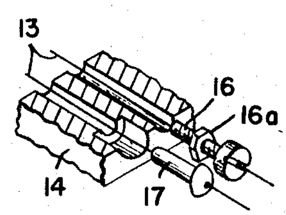


FIG. 3.

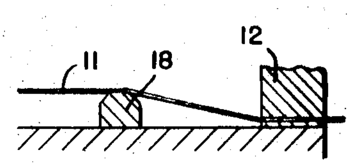


FIG. 9.

INVENTORS
ARTHUR DEREK GEORGE GROVES
and TORBEN HESSELBO
BY Arthur R Eglington
ATTORNEY

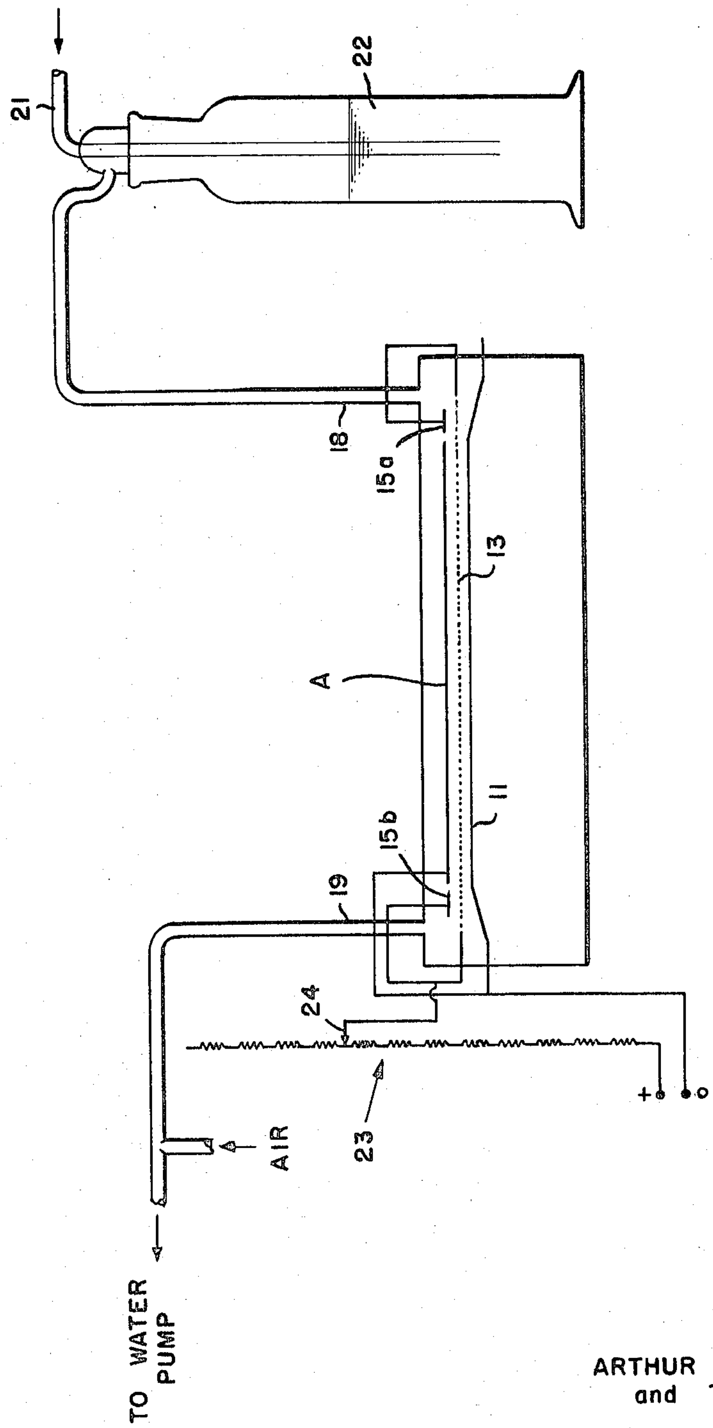


FIG. 4.

INVENTORS
ARTHUR DEREK GEORGE GROVES
and TORBEN HESSELBO
BY
Arthur R. Eglington
ATTORNEY

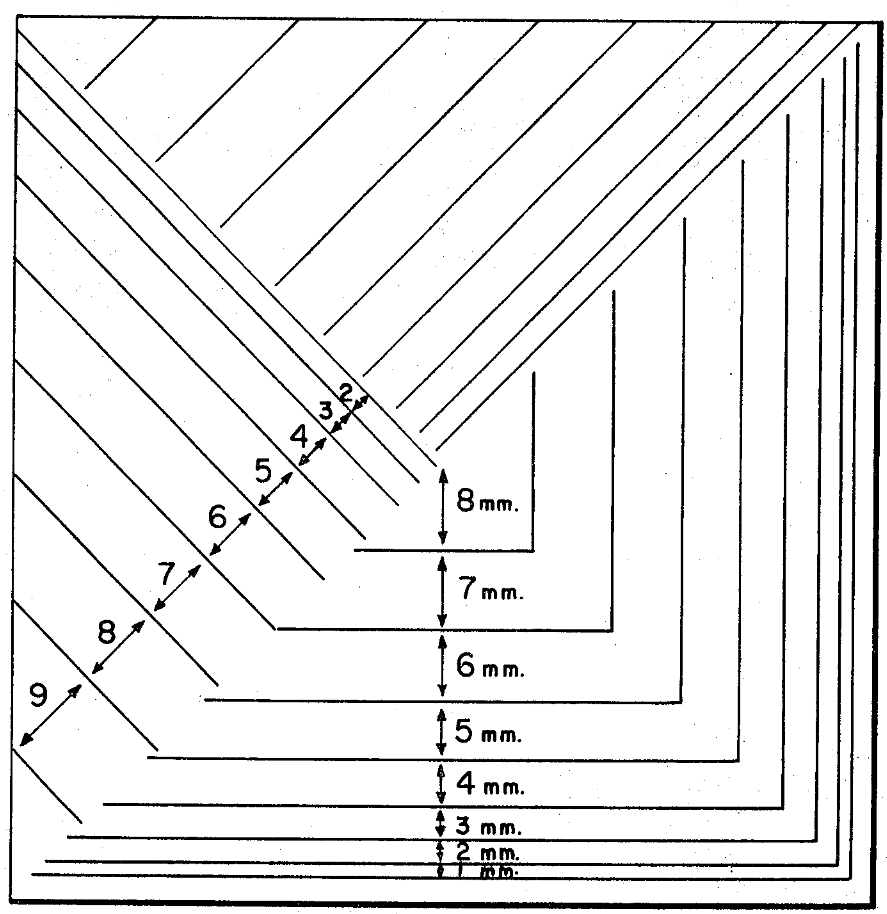


FIG. 5.

INVENTORS
ARTHUR DEREK GEORGE GROVES
and TORBEN HESSELBO
BY
Arthur R. Egington
ATTORNEY

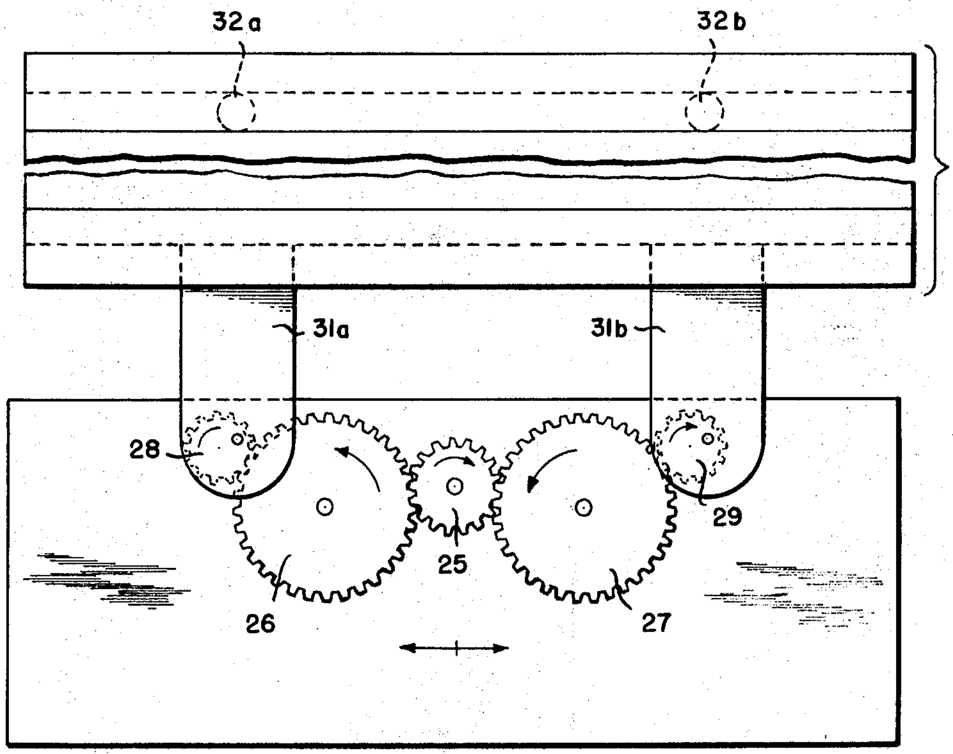


FIG. 6.

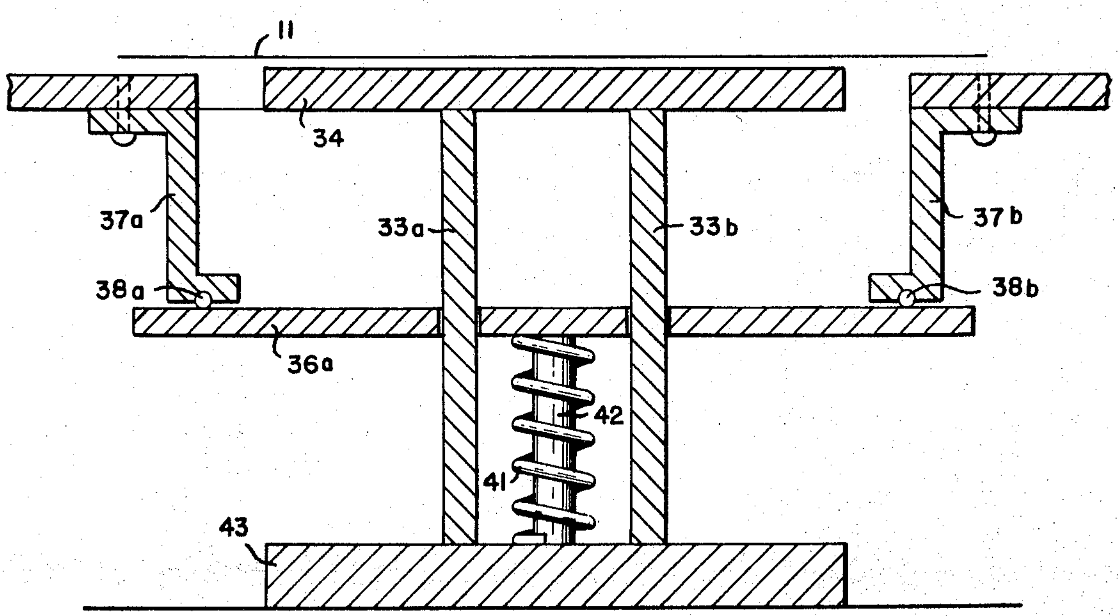


FIG. 8.

INVENTORS
ARTHUR DEREK GEORGE GROVES
and TORBEN HESSELBO
BY
Arthur R. Eglington
ATTORNEY

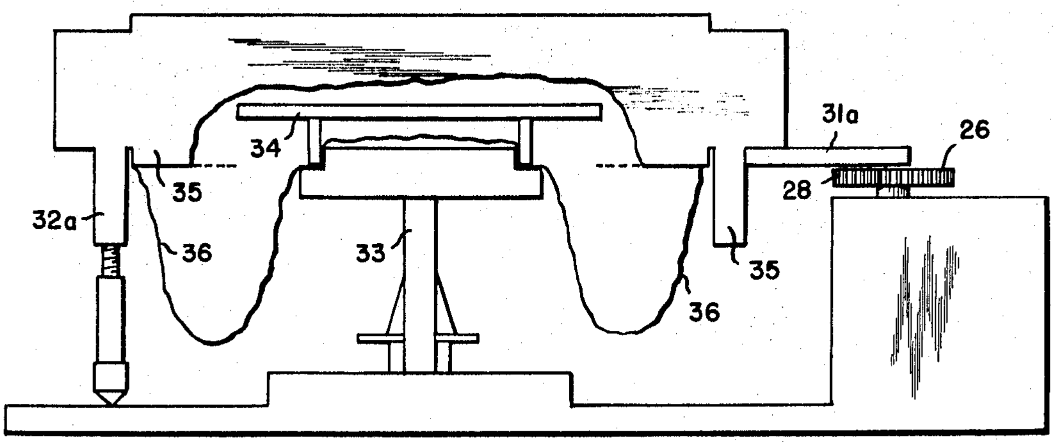


FIG. 7.

INVENTORS
ARTHUR DEREK GEORGE GROVES
and TORBEN HESSELBO
BY Arthur R. Eglington
ATTORNEY

SPARK CHAMBERS

This invention relates to spark chambers useful in obtaining pictorial data on radionuclide distribution on a radioactive pattern.

In biology, spark chambers can be used to visualize the distribution of gamma-emitting radionuclides in human organs. Also, they may be designed primarily to determine the distribution of beta-emitting isotopes on chromatographic or electrophoresis media, the interpretations of which are highly useful in medical and drug research.

A number of spark chambers are already known in which there are employed electrodes consisting of wires arranged so that electrical signals corresponding to spark positions can be extracted. One such crossed-wire spark chamber has been described by B. R. Pullan et al. in Nucleonics, Vol. 24, No. 7, July, 1966, pp. 72–75.

It comprises two parallel electrodes each consisting of a plurality of stretched wires mounted on polymethyl methacrylate frames having removable sections so that a radioactive pattern on a chromatography plate can be inserted inside the chamber in proximity to one of the wire electrodes. The wire electrodes are arranged so that the wires of one electrode are at right angles to the wires of the other electrode. The spark chamber is operated with a continuous flow of 90 percent argon and 10 methane gas and the electrodes are connected through a high resistance to a5,000-volt power supply.

When a particle traverses the space between the two crossed-wire electrodes, a spark jumps in the ionisation track, and its position is recorded by a camera arranged perpendicularly with respect to the planes of the crossed-wire electrodes. Enough spark images are collected to produce the desired picture.

It is an object of the present invention to obtain increased resolution, as compared with that which can be obtained with the known spark chambers such as the Pullan spark chamber described above, and to achieve more consistent efficiency over the whole area of the electrodes, since in the Pullan spark chamber it is difficult or impossible to avoid some wires being more efficient than others, resulting in a zoning pattern.

An additional advantage of the here disclosed improved spark chamber is that its improved resolution permits the evaluation of activity in the Ullberg Whole Body Sectioning Technique (Proc. 2nd U.N. International Conference on Peaceful Uses of Atomic Energy, 1958, 24, 248). Although this is not a chromatographic technique, it is of considerable interest to biochemists who wish to obtain an impression of the distribution of radioactivity in the body after administration of a radioactive drug. The method of whole body radioautography has been developed and perfected by Ullberg. Thin microtome sections through whole animals are transferred to adhesive tape and dried. After contact with an X-ray film a picture is obtained which reveals a considerable amount of detail. The spark chamber technique offers a means of obtaining very rapid information regarding average isotope load and thus an indication of the time required to obtain a satisfactory exposure on X-ray film. For comparison a radioactivity staircase (a strip of squares containing increasing amounts of radioactivity) may be included; the steps on the staircase may be calibrated directly in days of exposure.

In this application scanning is essential, especially if one intends to get an impression of the distribution of activity in small rats or mice.

In accordance with a first embodiment of the invention, there is provided a gastight spark chamber comprising two substantially parallel electrodes disposed in proximity within the chamber, at least the major part of the walls of the chamber which are substantially parallel to the electrodes being formed from or comprising a transparent material, which in the case of at least one of said walls is sufficiently thin to enable a radioactive particle from a radioactive pattern mounted externally of the spark chamber to pass therethrough, means for applying in use a high voltage to the electrodes from an external source and means for passing in use a counting gas through the chamber which is substantially gastight, the arrangement such that in use there is associated with the spark chamber manual or mechanical means for effecting movement of the spark chamber with respect to the externally mounted radioactive pattern in a plane substantially parallel to the planes of the electrodes.

In use the spark chamber and its associate movement effecting means will be assembled with a camera, preferably a Polariod camera, fixedly arranged facing one of the electrodes and perpendicularly with respect to the planes of the electrodes and with the radioactive pattern to be determined fixedly mounted on a flat rigid surface, for example, a glass or polymethyl methacrylate plate, which is positioned externally of the chamber, but closely adjacent to that wall of the chamber having its major part formed from or comprising a sufficiently thin transparent material to enable the radioactive particles to pass from the pattern into the electrode gap. An example of such a material is a polyester foil. The spark chamber will then be caused to move in a plane parallel to the electrodes by said movement effecting means so as to cause scanning of the radioactive pattern, while the camera is operated to provide a photographic record of the radioactivity distribution within the pattern.

The electrodes disposed within the spark chamber are advantageously each formed from a plurality of stretched wires mounted on a suitable frame, the electrodes being arranged with the wires of one electrode being substantially at right angles to the wires of the other electrode. However one or both of the electrodes may alternatively be in the form of plates, or may be formed into other configurations, such as coils capable of creating preferred sparking points.

Advantageously, in order to reduce spurious sparking at the edges of the electrodes when these are wire electrodes, two field control electrodes are positioned, respectively, adjacent the edge portions of one of the wire electrodes, and adjacent the central portion of the other wire electrode.

The body of the spark chamber is preferably constructed from a sufficiently strong synthetic plastics material, for example polymethyl methacrylate, or a laminate plastics material such as the commercially available phenolic sheet laminate sold under the trade name "Delaron," in the United Kingdom.

Any scanning movement described by the spark chamber during its operation will improve resolution to some extent. It will be appreciated therefore that the simplest is random movement by hand. Other movements which may readily be obtained by mechanical means are circular, linear, i.e., oblique relative to a straight line joining preferred sparking points, or lateral, i.e., a series of parallel movements.

Regardless of the nature of the electrodes, there will always be points at which a spark will preferentially occur, referred to herein as "preferred sparking points." These points are undesirable and their prominence in the photographic record or radioactivity distribution within the pattern is minimized by use of the mechanical scanning, which can be effected with the apparatus of the invention. In the case of circular scanning, it has been found that improved resolution is at a minimum if the diameter of the circle described is $nm/2$, where n is a small integer and m is the distance between the preferred sparking points. As the diameter of the circle increases, the effect of the novel-scanning movement is to increase the overall resolution, and to reduce the difference between maximum and minimum amounts of improvement in resolution. In practice best results are achieved when n is 6 or greater.

For a better understanding of the invention and to show how the same may be carried into effect, a spark chamber assembly in accordance with the first embodiment of the invention will not be described in greater detail, by way of example, in conjunction with the accompanying drawings in which:

FIG. 1 is an exploded view of a crossed-wire spark chamber;

FIG. 2 is an enlarged view, partially broken away, of one corner of component A of FIG. 1;

FIG. 3 is an enlarged detailed sectional view of the front edge, partially broken away, of either component C or D of FIG. 1; showing how the wires are affixed to the respective frames;

FIG. 4 is a diagrammatic view of the electrical and fluid connections to the spark chamber;

FIG. 5 shows a representative resolution test pattern;

FIG. 6 is a top plan view of a partially schematic illustration of how the spark chamber is connected in use to a drive mechanism;

FIG. 7 is a side elevation of the chamber of the embodiment of FIG. 6;

FIG. 8 is a somewhat schematic view in a vertical section of part of another embodiment of spark chamber; and

FIG. 9 is a vertical section, partially broken away, of the enlarged end portion of FIG. 1D.

Referring now to FIG. 1 in particular of the accompanying drawing, the spark chamber has a lower counting electrode D, comprising a plurality 11 of parallel wires typically 24 S.W.G. tinned-copper wires arranged one-eighth inch (3.1 mm.) apart in one plane, on a translucent plastic frame 12 such as of polymethyl methacrylate. In another plane is an upper electrode C, comprising a plurality of 0.005-inch-diameter stainless steel wires 13, arranged one-eighth inch (3.1 mm.) apart on a similar polymethyl methacrylate 14, or the like. Upper electrode C is positioned 0.1 inch (2.5 mm.) above the lower electrode D with its wires being at right angles with respect to those of said lower electrode. The planes of the wires should preferably be maintained parallel to within 0.001 inch. Together the two electrodes make about 4,000 wire cross points over an area 8 inches square.

The tinned-copper wires of the lower electrode D are bent downwardly near their ends (see FIG. 9) thus increasing the distance between the electrodes; this smoothes out the electric field, and counteracts a tendency to spurious sparking in these edge regions. Only the parallel portions of the wires in the electrodes are required to function in the chamber.

Further field control at the edges is achieved by the use of two additional electrodes 15*a* and 15*b*, which are made from strips of aluminum foil that are affixed on two opposite sides of the bottom surface of the frame of the upper electrode C, so as to be in register respectively with the aforementioned dual bent edge portions of the lower electrode E. These field electrodes are electrically connected to the upper electrode C.

A second field electrode A, connected to the lower electrode D, is positioned in a rectangular trough formed in the upper removable lid B of the chamber, the lid being formed from a transparent synthetic plastics material, such as polymethyl methacrylate. The field electrode A is made by winding a fine wire on to a thin transparent sheet of such synthetic plastics material at about ⅛-inch pitch (see FIG. 2).

In FIG. 3 is shown how the parallel wires of each electrode are affixed to the respective frames. Each wire has one adjustable brass screw 16 and nonadjacent rivet 17 as terminals, and by their alternate arrangement, just enough space may be obtained for the tensioning nuts. The screws and rivets alternately securing the fine steel or tinned-copper wires are preferably of brass. Wires which together form an electrode are electrically connected by using a conducting material, such as brass, for the construction of the bar 18 over which the wires bend.

The spark chamber is provided with inlet means 19 and outlet means 20 represented by the vertical tubes mounted on the frame of electrode C, for passing through a suitable counting gas, for example, argon bubbled through methylal at 0° C., or a mixture of 90 percent argon and 10 percent methane. In use, the electrode terminals are connected to a stable power source capable of supplying up to 5,000 volts.

The base of the spark chamber is provided with a removable trough E, comprising a frame formed from a synthetic plastics material, such as nylon, over which is stretched a thin foil of a plastics material, such as polyester foil, e.g., a commercially available 50 gauge polyethylene terephthalate foil, known as Melinex in the United Kingdom.

For use a Polaroid camera (not shown) is fixedly positioned above the assembled spark chamber, in a location perpendicular to the planes of the electrodes. The radioactive pattern is fixedly positioned below the spark chamber by mounting on a plate of transparent synthetic plastics material, like polymethyl methacrylate. The pattern is positioned beneath the plastics foil of inverted trough E, and at an appropriate distance therefrom.

To set up the spark chamber, the connections are made as shown diagrammatically in FIG. 4 of the accompanying drawing. If the counting gas employed is argon, saturated with methylal at 0° C., it is preferable to vent the apparatus to a fume upstream, or to remove the gases by gentle suction from a water pump.

Argon is introduced via conduit 21 into a vessel 22 containing methylal which is maintained about the temperature of melting ice. The methylal saturated counting gas passes to the spark chamber via conduit 18, flows therethrough, and out conduit 19, using a water pump (not shown) to provide a gentle vacuum.

The sets of wires 11 and 13 are tensioned so that they are free from kinks. Sufficient and approximately equal tension on all wires of one thickness is achieved by plucking the wires and listening to the note produced. To tension a wire the screw 16 (see FIG. 3) on the adjustable end is gently levered out and the nut 16*a* is turned until it touches the wall of the frame 14.

The resistance 23 shown in FIG. 4, consists of a plurality, typically 12, of 10 megaohm (M ohm) resistors in series. Connection is made by means of a crocodile clip 24, for easy selection of resistance. With high resistance (e.g., 120 M ohm) good stability well above the sparking threshold is obtained, but the dead time (i.e., the time the chamber is inoperative after a discharge) is inconveniently long for many purposes. With low resistance (e.g., 10–20 M ohm) the deal time is much improved but spurious sparking more readily occurs when the voltage is raised above the sparking threshold.

In operation, an intermediate resistance such as 80 M ohm is chosen initially. The empty chamber is flushed vigorously with the counting gas for 1 to 2 minutes, and the voltage is raised until sparking occurs (about 3000 volts with an 80 M ohm resistance). Switching on the voltage during the first minute of the flushing may cause a small explosion. A further 10 to 20 minutes of slower flushing often improves the picture and reduces the incidence of persistent sparking. The voltage is then raised another 500 Volts. A 10-minute exposure is made and the picture is developed.

This procedure will reveal persistently sparking points not immediately obvious. Persistent sparking may be caused by the sagging of a thin wire, by a flaw in a wire, by dust or by local contamination particularly with tritium. The spark chamber is therefore constructed in such a fashion that when necessary a wire may be replaced. Spurious sparking, i.e., an increase in background, may be caused by general contamination or by light, both artificial and natural. A treatment of the wires with a 1-percent solution of iodine in alcohol has been found to improve the performance of the spark chamber.

A Polaroid camera may be positioned above the spark chamber by means of a scaffolding (not shown) made from rods and clamps and the apparatus is placed in a darkroom (total darkness is not required). Alternatively, a black box may easily be built around the whole assembly for use in daylight.

A resolution test pattern as shown in FIG. 5 is next placed beneath the spark chamber. The pattern is formed by drawing in radioactive ink (10μC/ml. of tritium) on a thin layer plate or on a piece of cardboard. With the same setting as before and an exposure time of five to ten minutes, a picture is obtained which reveals nonfunctioning wires or areas. A wire may fail to spark if it is poorly connected electrically, or if the electric field is nonhomogeneous. After any faults discovered by the foregoing procedure have been rectified, the spark chamber is ready for use.

To evaluate a two-dimensional thin layer chromatogram, it is positioned beneath the insert E on a glass or polymethyl methacrylate plate.

The chamber is flushed with the counting gas, first vigorously from 1 to 3 minutes, and then more slowly. The flushing rate will depend on the quality of the sealing of the chamber. A suitable resistance is then chosen, by adjusting clip 24. It should be as large as possible, but if it is desired to detect weak spots in the presence of strong ones a short dead time, and consequently a small resistance may be needed. This is because the highly active spot will have a poor efficiency when the dead time is long, and the efficiency will be approximately the same for the strong and weak spot.

The voltage is turned up to as high a value as is possible without obtaining persistent sparking from any particular point. This value is typically 3,500 volts at 80 M ohm. The camera, which is placed at such a distance that the "active area" (20 cm. square) of the chamber just fills the picture (approximately 30 cm. between lens and thin layer plate using the Polaroid Land Camera 180). It is set at about f: 64 and infinity, using no additional optics. This will cause a desirable blurring of the image of the sparks. If attempts are made to focus on sparks it may be found that misleading impressions are obtained due to illumination of the background. This is particularly true if the radioactive spot is strongly colored.

The spark chamber is then cause to describe a circular movement by operation of the drive mechanism, shown in FIG. 6, the motor being operated at a speed such that the spark chamber completes 1 revolution every 45 seconds approximately.

The drive mechanism is shown diagrammatically in FIG. 6. A clockwork motor drives two gears 26 and 27 synchronously and through them drives adjustable cranks 28 and 29 at approximately 1 revolution per minute. The diameter of the scan is several mesh sizes, with the described cross-wire chamber preferably about 2 cm. Two horizontal supports 31*a* and 31*b*, attached to the spark chamber, rest on the cranks and translate the rotational movement to the chamber, which is otherwise only supported by two legs 32*a* and 32*b* with Teflon feet.

FIG. 7 shows the same arrangement in side elevational view. A vertically adjustable support 33 carries a platform 34 on which the thin layer plate is placed. In this embodiment the bottom trough E in FIG. 1 has been replaced with an open frame 35 onto which a bag 36 made from a flexible polyester sheet has been secured in a gastight manner.

Interposing this bag between the support 33 and platform 34 permit s scanning of tritium samples without loss of counting gas. The design does suffer from some disadvantage in having a large volume to be flushed with the counting gas, and consequently it takes a long time (e.g., 10–15 minutes even with vigorous purging) to obtain stable conditions.

If more penetrating radiation is employed, such as with 14C, it is better to use a frame with a membrane of stretched 50 gauge Melinex film in place of trough E of FIG. 1, and place the radioactive sample beneath it. In this way the chamber is easy to use for a series of samples since no purging is required between samples. As a bonus internal contamination of the chamber is eliminated; the Melinex sheet is easy to clean or replace.

Thus, through the closed end of bag 36 there protrudes into the chamber fixed platform 34, on which the radioactive pattern can be mounted and positioned in close proximity to the lower electrode. The flexibility of the plastics bag enables the electrodes to be moved in use by the drive mechanism while the pattern remains in a fixed position on the platform while maintaining the gastightness of the spark chamber.

A time exposure is now made in reasonable darkness. The time may be anything from 5 seconds to 1 hour depending on the amount of activity. In this period, a whole number of revolutions should preferably be completed by the spark chamber. To enable the activity relative to the thin layer chromatogram plate to be accurately located, it is useful to make an additional exposure on the same film; the high voltage is turned off, and with the room light on, a sharper (f: 90) picture is taken, exposing for a few seconds.

It will be appreciated that the use of the above-described spark chamber avoids contamination of the spark chamber internally with isotopes since the radioactive pattern is outside the chamber, and hence the chamber can be kept ready for immediate use by keeping it constantly flushed with the counting gas.

The spark chamber assembly as hereinbefore described is suitable for use with most isotopes. However it is unsuitable for use with a weak emitter such as tritium, since it is not normally possible for radioactive particles from an externally mounted weak emitter to penetrate the foil of plastics material in the removable insert G. In another embodiment of this invention, this disadvantage may be obviated by positioning the radioactive pattern within the spark chamber in a manner such that the pattern can remain in a fixed position within the chamber, while the electrodes are enabled to move in a desired manner so as to scan the pattern as with the spark chamber hereinabove described.

Hence in accordance with a just described second embodiment of the invention there is provided: a spark chamber comprising two substantially parallel electrodes disposed substantially horizontally in proximity within the chamber, at least the major part of the upper wall of the chamber which is substantially parallel to the electrodes being formed from or comprising a transparent material so as to allow observation and photographing of the electrodes when required; a platform on which in use a radioactive pattern can be positioned within the spark chamber in proximity to the lower electrode; means for applying in use a high voltage to the electrodes from an external source through a high resistance; and means for passing in use a counting as through the chamber which is substantially gastight; the arrangement being such that in use there is novelly associated with the spark chamber manual or mechanical means for effecting movement of the electrodes with respect to the internally positioned radioactive pattern, in a plane substantially parallel to the planes of the electrodes.

Advantageously, the spark chamber is provided with means for effecting relative movement of the platform and the electrodes whereby the distance of the radioactive pattern from the lower electrode can be varied.

It will be appreciated that while the foregoing second embodiment is principally of use with weak emitters, it can also be used with strong emitters, but in the latter case contamination of the spark chamber with isotopes may occur and hence decontamination may have to be effected before further use.

In FIG. 8 there is shown another alternative embodiment for insert E of FIG. 1, in order to provide a spark chamber suitable for use with a weak emitter such as tritium. In this arrangement the lower member 36*a* of the chamber is constructed from a solid material, instead of from a flexible plastics film. The sidewalls 37*a* and 37*b* of the chamber are movably connected to the bottom wall of the chamber by a gastight joint, formed from beading 38*a* and 38*b* of a low-friction material, for example, polytetrafluoroethylene, in conjunction with a conventional gastight grease. Platform 34 is supported by screw jack pillars 33*a* and 33*b*, provided with upwardly biased light spring 41, which is coiled upon shaft 42, secured to the bottom surface of member 36*a* and base plate 43. Thus, the sides and top member (not shown), and hence the electrodes, of the spark chamber can be moved in use, while the bottom wall 36*a* of the chamber and the radioactive pattern (not shown) mounted inside the chamber and adjacent the lower electrode can remain stationary on platform 34.

The scanning chambers are operated in much the same fashion as the stationary ones, the main differences being the following:

When scanning, the frequency of coincidence of spark images will be reduced, and a longer exposure will therefore be beneficial. Furthermore, slight blurring of the picture is no longer desirable and best results are obtained by focusing on the electrodes, using a closeup attachment. When sufficient time or radioactivity is available a small aperture should be used, e.g., f:90 for the cross-wire chamber.

What is claimed is:

1. A radioactive scanning device consisting of:

a. a substantially gastight spark chamber comprising two substantially parallel electrodes disposed in close proximity within said chamber;
b. at least one of the walls of said chamber comprising a translucent material so as to allow visual observation thereof by a camera positioned fixedly thereabove and said wall or walls being substantially parallel to said electrodes;
c. at least the other of said walls being sufficiently thin so as to enable a radioactive particle to pass therethrough;
d. a support means disposed externally of said chamber and adapted to hold a radioactive pattern in proximity to said other wall of said chamber;
e. an external source for applying an adjustable high-voltage through a high resistance to said electrodes;
f. means for passing a counting gas through said chamber;
g. a freely rotatable mount embracing said chamber; and
h. means for effecting mechanical movement of said mount in a plane substantially parallel to the plane of said radioactive pattern.

2. A scanning device as set forth in claim 1 in which said movement is circular.

3. A radioactive scanning device consisting of:
a. a substantially gastight spark chamber comprising two substantially parallel electrodes disposed in close proximity within said chamber;
b. at least one of the walls of said chamber comprising a translucent material so as to allow visual observation thereof and being substantially parallel to said electrodes;
c. substantially all of the other wall comprising a flexible gas impervious material thereby defining a gastight chamber;
d. a support means disposed internally of said chamber and adapted to hold a radioactive pattern in proximity to one of said electrodes;
e. an eternal source for applying an adjustable high-voltage through a high resistance to said electrodes;
f. means for passing a counting gas through said chamber;
g. a freely rotatable mount embracing said chamber; and
h. means for effecting mechanical movement of said mount in a plane substantially parallel to the plane of said radioactive pattern.

4. A scanning device as set forth in claim 3 in which said movement is circular.