

[54] COLLIMATOR

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Related U.S. Application Data

- [62] Division of Ser. No. 48,166, June 22, 1970, Pat. No. 3,688,113.
[52] U.S. Cl. **250/505, 250/71.5 S**
[51] Int. Cl. **G21f 5/02**
[58] Field of Search. **250/61.5, 71.5, 105, 250/71.5 S, 71.55**

[56] **References Cited**

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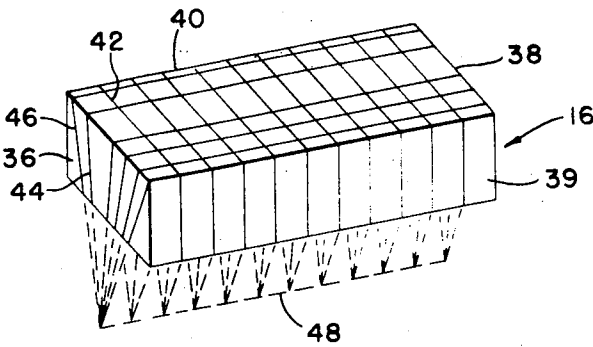
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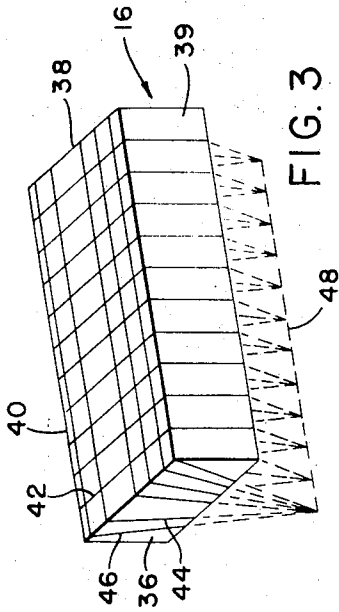
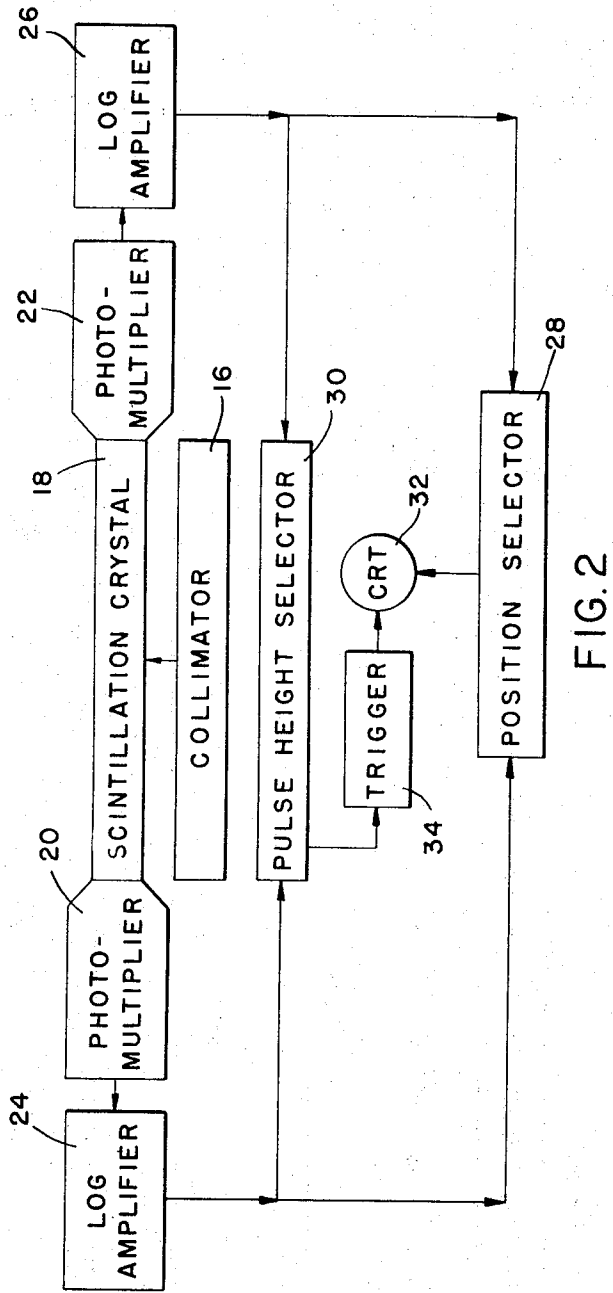
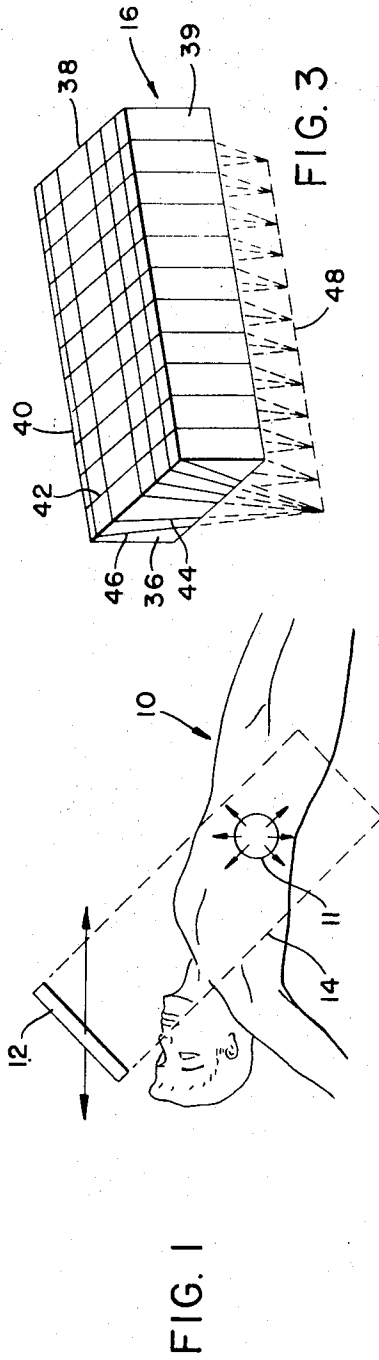
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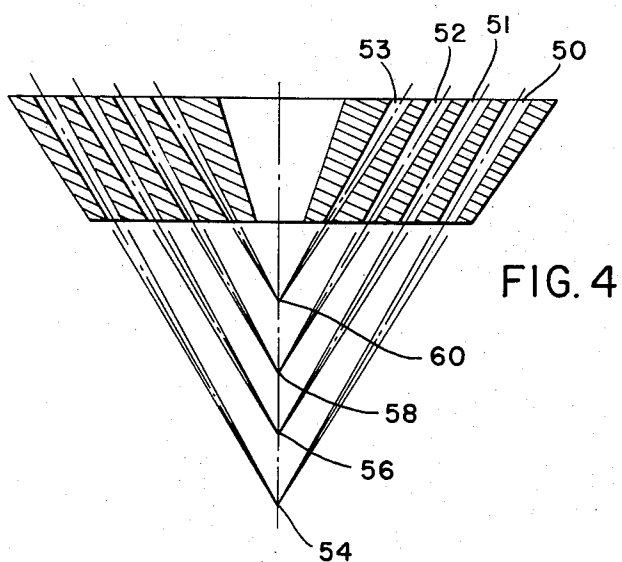
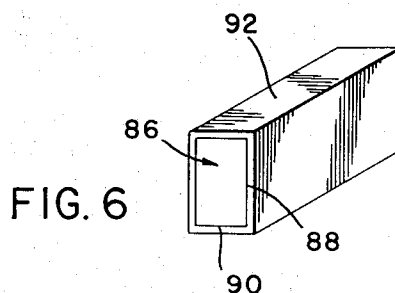
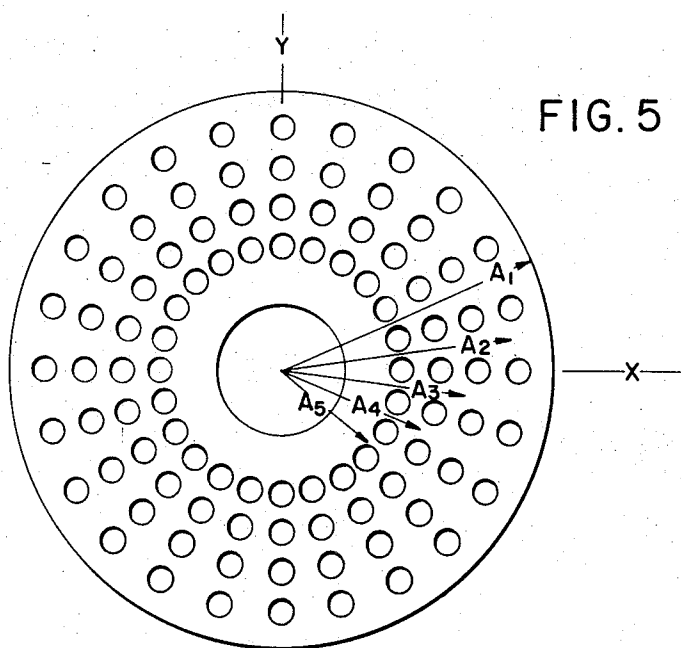
ABSTRACT

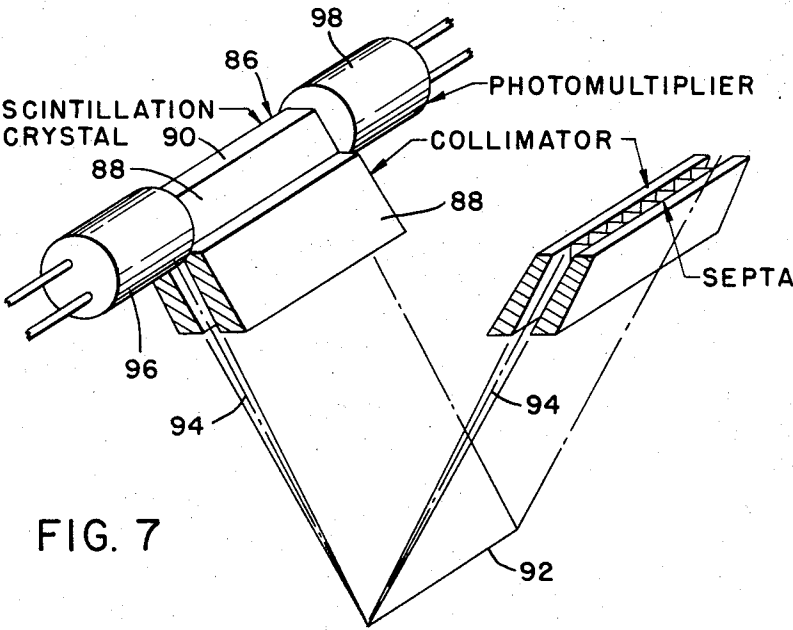
A collimator having a front and rear and a longitudinal axis passing from the front to the rear. Spaced septa between the front and the rear defining openings and including a plurality of longitudinal sides parallel to the longitudinal axis and converging downwardly at different angles to form channels which converge to a single focal line. The septa further includes spaced parallel sides transverse to the longitudinal axis and intersecting with the longitudinal sides. The parallel sides form transverse channels which are non-focusing along the focal line.

2 Claims, 7 Drawing Figures









COLLIMATOR

This is a division of application Ser. No. 48,166, filed June 22, 1970 and now U.S. Pat. No. 3,688,113.

BACKGROUND OF THE INVENTION

In order to study human or other organs the practice has developed of making such organs radioactive. The patient usually takes medication containing amounts of radioactive material.

The radioactive material which is commonly used gives off gamma rays. It is usually easier and more effective to change the gamma rays to visible light radiation than to try to detect the gamma rays directly. However, the detection and conversion of gamma rays has its own difficulties. These problems include the discrimination between radiation resulting from photoelectric effect and Compton effect and a determination of the location of the radiation within the source of radiation.

Many types of radiation scanners have been developed in order to detect a radiation pattern within the organs. In this respect, the following articles have been published:

1. Anger, H. O.: The Scintillation Camera for Radioisotope Localization. [In] Radioisotope in der Localisationsdiagnostik, ed. by G. Hoffman and K. Scheer. Stuttgart, F. K. Schottauer, 1967.
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13. Patton, J., Brill, A. B., Erickson, J., Cook, W. E., and Johnston, R. E.: A New Approach to Mapping Three-Dimensional Radionuclide Distributions. (abst.) J. Nuclear Med. 10:363, June 1969.
14. Rotenberg, A. D.: Body Scanning. Ph.D. Thesis, Univ. of Toronto, November 1962, pp. 73-76.

Past radiation sensitive scanners have been able to obtain relatively good resolution but have inherent limitations. They are normally designed to be focused at a single point or very small area passing through the source. Investigation of a large source requires an excessive amount of time in order to scan the entire area under observation. As a practical matter, patients may tire and move during the scan thus jeopardizing the investigation.

Scintillation cameras which generally observe an area rather than a point have sought to solve the excessive time problem of the scanner. They have been relatively successful in this respect since they take much less time than a scanner to observe a given area. However, the scintillation camera such as that disclosed in the Anger U.S. Pat. No. 3,011,057 also has its limitations. Because it must observe a relatively large two-dimensional area at one time, the resolution is not as good as a scanner. This results because the phototubes in the Anger patent observe a large scintillation crystal and it views some scattering of light.

The present invention relates to a radiation scanning device and, more particularly, to a device which is well adapted for mapping radioisotope distributions within a human body. A number of schemes have been developed for utilizing gamma detecting scintillation crystals for scanning selected portions of the human body to determine radioisotope distributions. Most schemes however produce a two-dimensional representation of the three-dimensional distribution. This results in a decreased resolution of a lesion because of superimposing and overlying activity. To enhance the resolution, the use of body-section scanning is proposed. The layer-by-layer analysis which can be attained by tomoscanning allows a significant enhancement of detail and contrast by elimination of the superimposing and obscuring activity. Although many approaches to section scanning have been suggested and tried, all may be grouped into the general procedure of scanning with collimators inclined to the plane of interest. This method was initiated by others and often goes by the name "longitudinal section scanning". The general procedure is to obtain separate scans with a collimator at various angles to the plane of interest. The resulting separate scans are superimposed to give a reinforcement at a given plane.

This invention has combined the advantages of a camera and a scanner in order to provide a three-dimensional well defined image which can be formed in a relatively short amount of time. This invention provides for the use of an elongated collimator and a scintillation crystal which usually view the entire width of the source. A single longitudinal scan enables the collimator to view the entire area of the source. A second scan from a different direction provides enough additional information for determining the depth of the source.

This invention also provides a means and technique for detecting the locations of scintillations in a crystal with a high degree of accuracy in order to provide good

resolution of the source of the radiation. This improved resolution is obtained by means of a system utilizing logarithms of the amplitudes of the pulses emanating from photomultiplier tubes.

SUMMARY OF THE INVENTION

This invention is directed to a collimator which focuses to a single focal line. It includes a body having a front and rear and a longitudinal axis passing therebetween. Spaced septa define openings and include a plurality of longitudinal sides parallel to the longitudinal axis which converge downwardly at different angles to form channels. The septa further include spaced parallel sides transverse to the longitudinal axis and intersecting with the longitudinal sides which form transverse channels which are non-focusing along the focal line.

FIG. 1 is a schematic representation of the use of the invention of this application.

FIG. 2 is a block diagram of the elements of this radiation sensitive device.

FIG. 3 is a perspective view of the collimator used in this system.

FIG. 4 is a cross-sectional view of an alternate type of collimator.

FIG. 5 is a top sectional view of still another alternate type of collimator.

FIG. 6 is a perspective view of the scintillation crystal.

FIG. 7 is a schematic representative of the combined scintillation crystal and collimator.

PREFERRED EMBODIMENT

General System

As illustrated in FIG. 1, this invention generally relates to a device for sensing radiation from a source which can be an organ of a human body. An individual will, after taking a radioactive substance in medication, have a concentration of radiation in a given organ 11. The radiation emanating from the source 11, usually gamma rays, is sensed by a detector 12. In a given position, the detector 12 has a rectangular field 14 of sensing. In actual practice, the plane 14 has a given depth so there is actually a wedge-shaped channel viewing the source at any given moment.

The detector 12 is able to move in either direction across the source and thus detect the radiation. The detector 12 has a definite viewing angle that can be varied in order to view the source from different directions. As explained in more detail hereinafter viewing the radioactive source from different directions allows an investigation of different reference planes within the source. This type of study is generally referred to as tomography.

A block diagram of the system for the tomographic scanner of this invention is illustrated in FIG. 2. A collimator 16 intercepts radiation normally gamma rays from a source and allows transmission of part to a scintillation crystal 18 which is usually in close proximity thereto. The scintillation crystal converts to gamma rays to visible light. Means for converting the visible light to electrical pulses includes photomultiplier tubes 20 and 22 which are located at each end of the scintillation crystal 18. The electrical pulses are subsequently transmitted respectively to the amplifiers 24 and 26. The collimator, scintillation crystal, means for converting the visible light to electrical pulses and necessary

physical and/or electrical connections make up the essentials of means for detecting radiation from a source of radiation.

The amplifiers 24 and 26 transmit their signals to a pulse height selector and a position selector which combines for a read out on a cathode ray tube. The amplifiers as will be explained in more detail below change the amplitudes of the electrical pulses from the photomultiplier tubes to logarithms of the amplitudes before transmitting them to the pulse height selector. The amplifier which converts the amplitudes to logarithms of the amplitudes, pulse height selector and the necessary electrical connections make up a means for operating on the output of the amplitudes of the electrical pulses in order to produce a substantially constant output for radiation of given energy levels regardless of the position of scintillations in the crystals.

Means for determining the positions of scintillations in the crystal include a position selector 28 which is basically circuitry for subtracting the logarithms transmitted by the amplifier 24 and 26. The position selector 28 further includes mechanisms for scanning the source while recording information concerning the radiation and relative positions of the scanner and source.

A known circuit 34 triggers a cathode ray tube 32 when the pulse height selector accepts a signal. Simultaneously the position selector gives information to the cathode ray tube 32 in order to properly place the pulse on coordinate axes.

COLLIMATOR

The collimator 16, illustrated in FIG. 3 has a front 36, rear 38 and sides 39 and 40 A longitudinal axis passes from the front to the rear. Septa 42 are generally parallel to each other from the front 36 and to the rear 38. In this respect the septa form a non-focusing system in the longitudinal direction of the collimator 16. The septa 42 form openings or channels 44 with longitudinal sides 46 which are parallel to the longitudinal axis and which converge downwardly to a single focal line 48.

An alternate embodiment of the collimator is illustrated in FIG. 4 and has pairs of openings 50, 51, 52 and 53 defined by sides which converge downwardly to different focal lines 54, 56, 58 and 60 respectively. The focal lines 54, 56, 58 and 60 are formed along a plane perpendicular to the plane of the collimator in order to allow the collimator to be aimed. A cross-section of the collimator is illustrated in FIG. 4, and focal lines 54, 56, 58 and 60 of the collimator extend the length of the collimator. By utilization of focal lines at different distances from the collimator different depths and areas of viewing can be made simultaneously. With the use of the collimator of FIG. 4, however, it would be necessary to use a pair of scintillation crystals for each pair of openings 50 which meets at a common focal line.

The dimensions of the collimator are selected to provide a desired resolution distance at the focal line and to have a field of view which is as uniform as possible. In practice, focal lengths of 6 to 20 cm have been found to be successful. This collimator is of a general design which is a cross between a focusing collimator and a straight through or non-focusing collimator because it is focusing in one direction and non-focusing in the perpendicular direction. In general collimators are composed of a heavy dense material such as lead.

An alternate embodiment of the multiplane collimator of FIG. 4 is shown in FIG. 5 where the shape is circular and a series of channels in a ring form the set that refers to one plane. In this collimator system gamma ray detection consists of a thin circular crystal and an array of photomultipliers as illustrated by the Anger U.S. Pat. No. 3,011,037 which is incorporated by reference herein. A modification to the Anger summing circuit is necessary, however, in order to obtain depth information with this collimator. The Anger method yields coordinate positions X and y of a scintillation as noted in FIG. 5. If, for example, it is desired to consider depth layer 56 of FIG. 4, then only the response for the set of channels 51 is wanted. In order to obtain this response, the output of the Anger system must be transmitted to electrical circuits which add the information as X^2 plus y^2 . If this sum has a value between A_2^2 and A_3^2 then the scintillation must have occurred from the set of channels 51. In a similar manner any other level can be determined. The net result is that the use of the collimator of FIG. 5 and known circuitry can convert a two-dimensional camera such as Angers to a tomographic camera.

SCINTILLATION CRYSTAL

As illustrated in FIGS. 6 and 7, the scintillation crystal 86 has a generally rectangular cross-section which is uniform along its length. A rectangular cross-section was chosen because of favorable attenuation. Other configurations where the cross-sectional height is different than the width would also be acceptable. The height 88 is greater than the width 90. A range of heights of 1 inch to 2 inches for sodium iodide has been successfully used in this invention. It is anticipated, however, that deviations from this height may also prove successful. The width of the scintillation crystal is approximately one-half inch and some deviation may also be made from this dimension. A coating 92 of highly reflective material such as magnesium oxide covers the scintillation crystal 86 in order to decrease the attenuation of radiation within the crystal.

In use, the scintillation crystal 86 is mounted in proximity to the collimator as illustrated in FIG. 7. The collimator 88 is focused to converge at a focal line 92. Radiation received within the wedge-shaped channel 94 is received by and transmitted through the collimator 88 to the scintillation crystal 86 where a scintillation occurs which changes gamma radiation to visible light.

While the channel 94 is wedge-shaped, the wedge is really a complex configuration. Its sides converge in a nearly linear fashion but are slightly curved. After the focal line the sides diverge more rapidly than they converged.

The shape of the scintillation crystals was chosen to give an attenuation factor which would produce an acceptable slope to give realistic differences of the logarithms of the amplitudes so they could be detected as well as to give enough amplitudes to maintain an acceptable uncertainty. In order to accomplish these ends the scintillation crystal was chosen to have a rectangular shape with a height of approximately 1 to 2 inches and a width of approximately one-half inch. This particular shape gave an attenuation constant which was satisfactory. In order to keep the amplitude of the pulses within the scintillation crystal at a relatively high level so they could be detected with acceptable uncertainty the scintillation crystal was covered with a high reflective coating such as magnesium oxide.

It should be understood that while the above described preferred embodiments give specific details, modifications will be available to those knowledgeable in the art. For example, scintillation crystals could possibly be replaced by more sophisticated, solid state items which translate gamma radiation to visible light radiation.

I claim:

1. A collimator comprising:

a body having a front and rear and a longitudinal axis passing from the front to the rear;
spaced septa between the front and the rear defining openings and including a plurality of longitudinal sides parallel to the longitudinal axis, said longitudinal sides converging downwardly at different angles to form channels which converge to a single focal line which is parallel to the longitudinal axis of the collimator and the septa further including spaced parallel sides transverse to the longitudinal axis and intersecting with the longitudinal sides, the parallel sides forming transverse channels which are non-focusing along the focal line.

2. The collimator of claim 1 wherein the longitudinal sides are symmetric about either side of a line passing from the front to the rear and are substantially perpendicular to the parallel sides.

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