United States Patent [19]

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[11] **3,812,361**

[45] **May 21, 1974**

[54] **PROCESS AND APPARATUS FOR VISUALIZING GAMMA RAY IMAGES**

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[22] Filed: **Nov. 3, 1971**

[21] Appl. No.: **195,345**

[52] **U.S. Cl.** **250/370,** 250/366

[51] **Int. Cl.** **G01t 1/24**

[58] **Field of Search**.... 250/71.5 R, 83.3 R, 213 VT, 250/366, 370; 315/169 T

[56] **References Cited**

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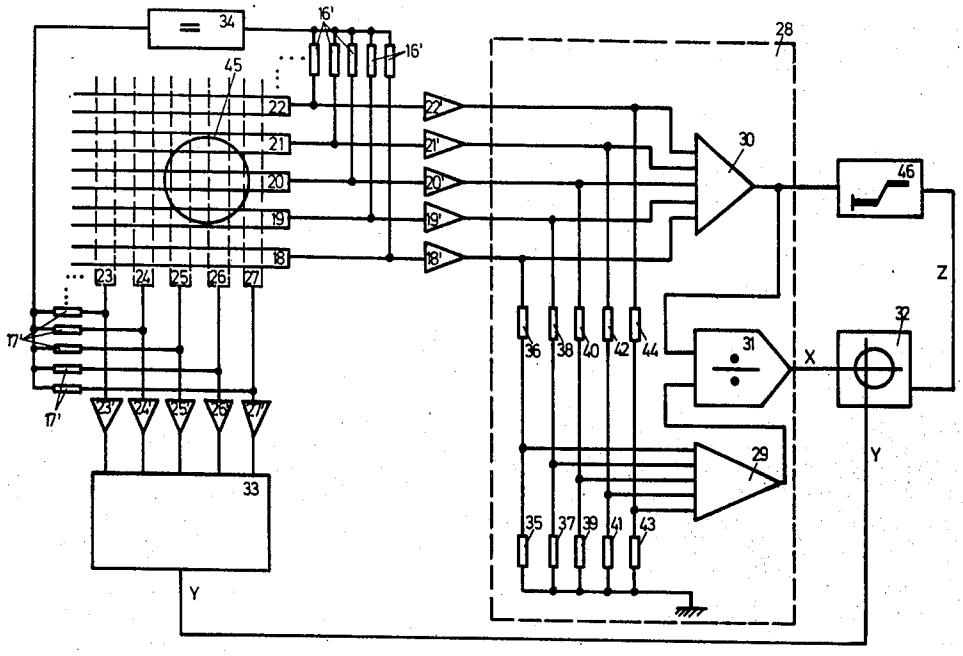
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[57] **ABSTRACT**

A process and a device for visualizing gamma ray images use a semi-conducting plate which is provided on both sides with electrode strips extending parallel to each other, the direction of the strips on one side extending at an angle to the direction of strips on the other side. The invention is particularly characterized in that the gamma quanta are changed into electron bundles and are represented upon the semi-conducting plate. The electrode strips are connected with a device for core formation which produces representable local signals localizing the electron bundle striking the semi-conducting plate.

5 Claims, 3 Drawing Figures



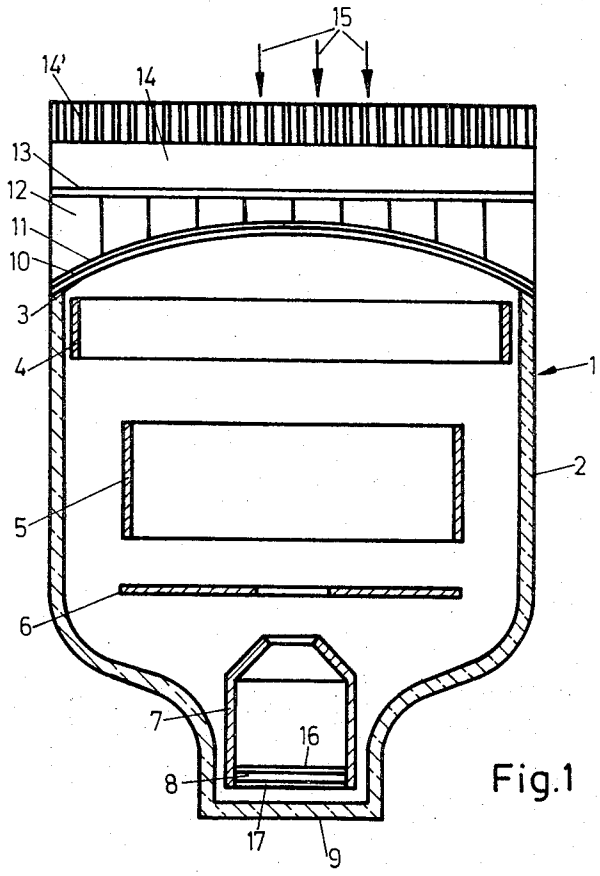


Fig.1

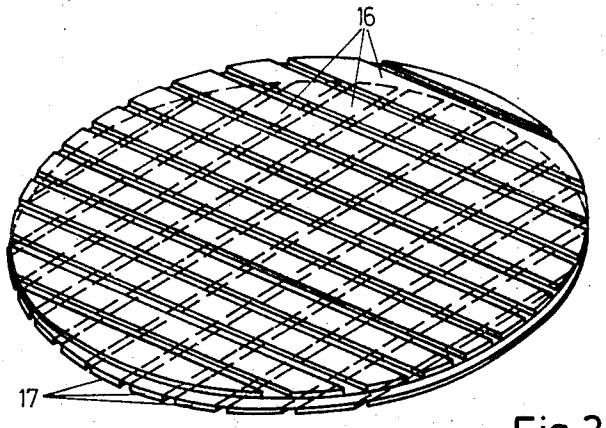


Fig.2

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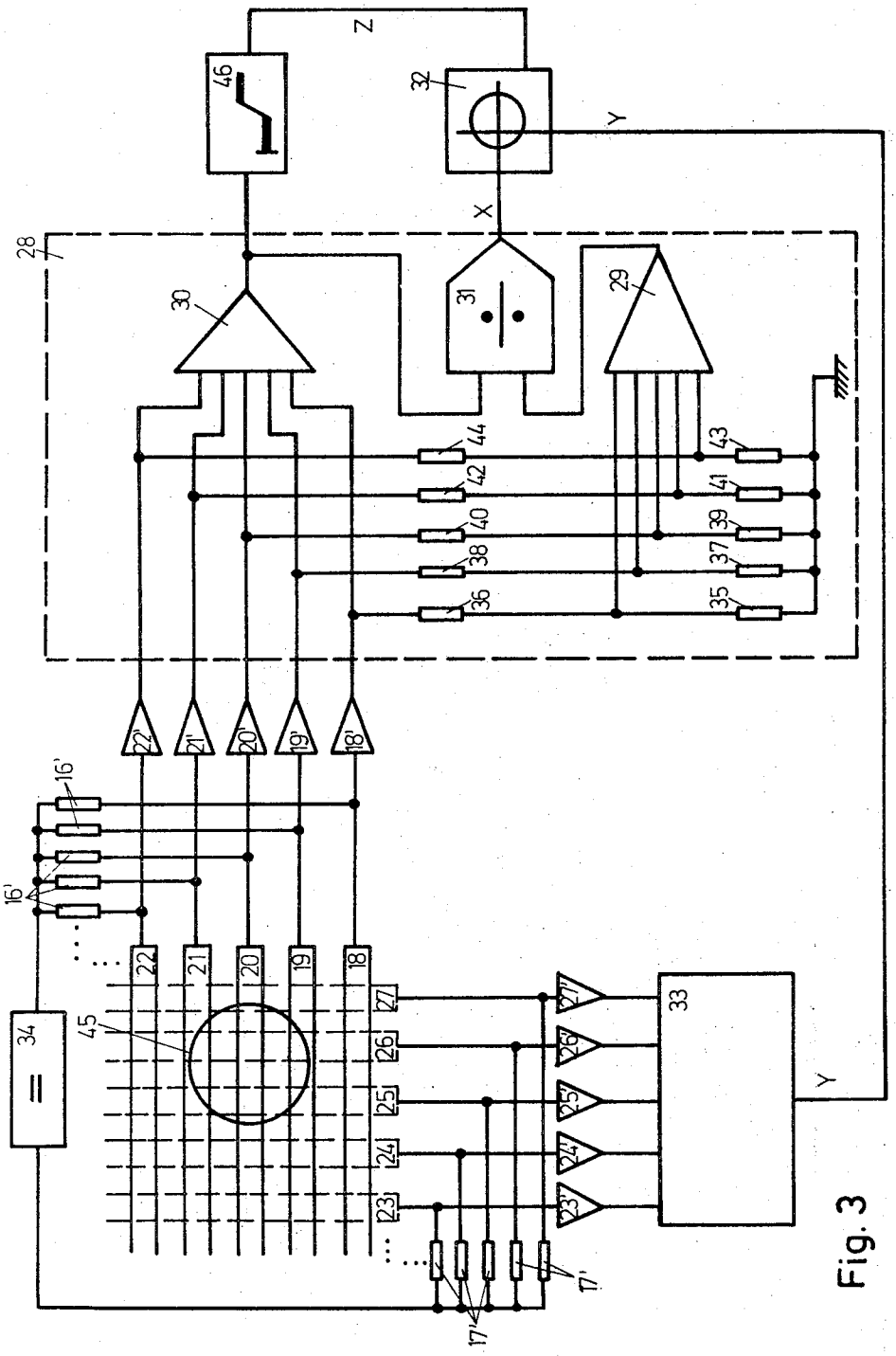


Fig. 3

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PROCESS AND APPARATUS FOR VISUALIZING GAMMA RAY IMAGES

This invention relates to a process and a device for visualizing gamma ray images by means of a semi-conducting plate which makes possible to determine the location of absorption of an ionizing particle, in that it is provided on both sides with electrode strips extending parallel to each other, whereby the direction of the strips upon one side forms an angle with the direction of strips upon the other side. A device of this type is used, for example, in the nuclear medical diagnosis to make visible the distribution of incorporated radioactive substances which are preferably fed to certain organs or sick tissues.

Semi-conducting devices, particularly in the shape of semi-conducting plates, which make possible a localization of the absorption place of ionized ray emission, are known in the art. These devices consist, for example, of a semi-conducting plate the opposed principal surfaces of which are provided with parallel electrode strips, whereby the direction of strips upon one side forms an angle with the strips upon the other side, preferably an angle of 90°. The contacts between the electrodes and the semi-conducting plate have upon one side a rectifying and upon the other side an ohmic characteristic.

These known semi-conducting detectors have not found acceptance up to now since due to the small produceable layer strengths they have only a small absorpton probability and thus a small output for the gamma rays. Furthermore, they can not be made of sufficiently large surface sizes, to be able to be used directly for representing the distribution of radioactive substances in an organism.

An object of the present invention is to eliminate these drawbacks of existing constructions.

Other objects will become apparent in the course of the following specification.

In the accomplishment of the objectives of the present invention it was found desirable to transform the gamma ray image into an electron ray image which is then represented upon the semi-conducting plate, the electrode strips of which are connected with a device for core formation and for producing representable local signals for localizing the electron bundle striking the semi-conducting plate.

The transformation into the electron image can be carried out with a suitable device, for example, a scintillator-photo-cathode combination, such as is used for image changers known in X-ray technology and isotope diagnosis. They consist mostly of a vacuum tube containing a light screen behind the inlet surface which is followed in optical contact by the actual photo-cathode layer. The electron ray image is thereupon produced by a system of electrodes to which voltages of different values are applied, electron optically upon a semi-conducting plate, possibly of smaller size.

As compared to known devices the device of the present invention has the advantage that it can use semi-conducting plates with a small diameter. Furthermore, the proof probability of gamma radiation is considerably better due to the good absorption of electrons, than in the case of direct reception of gamma ray image in the semi-conducting layer.

The proof probability can be primarily increased by the use of a scintillation crystal, such as thallium activated sodium iodide, as primary ray detector. This has

the advantage that layers of great thickness can be used which have great absorption probability. These crystals can be produced in sufficiently large sizes as single crystals having the size of the bodily organ being examined. Instead of a single crystal of corresponding size a matrix of many individual crystals can be used which are located one next to the other. The releasing capacity of this arrangement is limited, however, by the size of the screen of the crystal matrix. There is also the possibility of using steamed upon layers of scintillating material.

The natural result of large layer thicknesses is that the light produced during an absorption procedure in the scintillation crystal is widened before it reaches the photo-cathode coupled to the crystal. The resulting absorption of light division resulting from a single gamma quantum and thus the distribution of electrons released from the photo-cathode, have a more or less great widening dependant upon the geometry of the arrangement. The electornic optical representation of this practically gauss-shaped light and electron division upon the semi-conducting plate results, therefore, in an image spot with corresponding extension and intensity distribution of electrons striking the semi-conducting plate.

The location of the maximum or the core point of this intensity distribution corresponds to the location of the striking point of the initial gamma quantum. In order to localize this striking point it is therefore necessary to determine the core point of the intensity distribution. This can take place by determining the corresponding core points in the two directions provided by the strip-shaped contacts.

To make possible the core determination with sufficient precision the strip-shaped screen formulation of the semi-conducting contacting unit must be so narrow, or the size of the electronic optical image must be so selected, that the image spot of the electronic distribution should cover at least a surface upon which there are nine (3×3) intersection points of the electrodes. In case of semi-conducting plates used in electronic optical vacuum changers from about 10 to 140 strips are sufficient for the above purposes in order to produce an image sharpness required for images now in use.

The semi-conducting plate can consist of known semi-conductors, such as, for example, silicon or germanium. Electrons striking the plate and absorbed by it have through the electrostatic acceleration in an electronic optical representation depending upon the acceleration voltage an energy of 10 to 40 keV and they produce in the striken layer pairs of holes of electrons which are collected upon the strip-like electrodes. Consequently, charging impulses are produced upon the electrode strips the size of which depends in addition to the acceleration voltage upon the number of the striking electrons. Thus an impulse height distribution will be registered upon the participating electrode strips which corresponds to the electron distribution in the image spot. Then the core point of the x and y coordinates (the two strip directions) can be easily determined in a known manner, for example, by means of a digital calculator or by the use of analogous circuits as they are used, for example, in a gamma camera according to Anger. The reproduction of the image is possible by known reproducing devices, such as, for example, an XY-oscillograph, a telescopic screen, image printers, etc.

The sum of all impulse values appearing upon the electrode strip is proportional to the totally formed charge carrier, i.e., when the acceleration voltage is given, to the number of all striking electrons. The number of electrons is proportional to the energy of the absorbed gamma quantum, to the extent that it is absorbed by the photo effect. By analysing the impulse value of the total signal, for example, by means of a one channel discriminator, it is possible to find certain occurrences, for example, those released by a gamma quantum of a specific energy. This makes it possible to separate rays which are different in energy, for example, to separate distributing stray rays or underground rays from the useful rays. In order to provide a summing signal it is sufficient to use only signals upon the electrode strips upon one of the surfaces of the semiconducting plate, since both sides of the semiconducting plate participate in the collection of formed charge carriers.

The invention will appear more clearly from the following detailed description when taken in connection with the accompanying drawings showing by way of example only, a preferred embodiment of the inventive idea.

In the drawings:

FIG. 1 is a sectiln through an electronic optical image magnifier wherein in accordance with the present invention the released electron bundle is represented upon a semi-conducting plate as an outlet screen.

FIG. 2 is a perspective view of a semi-conducting plate on an enlarged scale.

FIG. 3 is a diagram of the electronic circuit by means of which the core points of the striking surfaces of the electron bundle upon the semi-conducting plate can be determined.

FIG. 1 shows an image magnifier **1** with a glass case **2.** The photo-cathode layer **3** located within the case at its inlet side consists in the illustrated device of antimony activated by caesium. It is followed by annular electrodes **4, 5** and **6** extending concentrically to the cathode **3,** as well as the anode **7.** The anode is closed by a semi-conducting plate **8** lying at the outlet window **9** of the image magnifier. In front of the inlet window **10** there is provided the light conducting device **12** having silicon oil used as the optical coupling layer **11** and provided at its free end with a further coupling layer **13** which also consists of silicon oil and which is connected to the scintillation crystal **14.**

The silicon oil can be replaced by other coupling means, such as the known optical luting.

In the illustrated example, organs marked with gamma ray conductors are pictured in the crystal **14** with the use of a parallel hole collimator **14'**. Gamma rays passing through the holes of the collimator **14'** which are indicated by arrows **15** in FIG. **1,** are absorbed in the scintillation crystal **14** while sending out light. The light thus produced is transmitted through the glass rods **12** serving as light conductors and having a diameter of 7 mm, to the photo-cathode **3** and releases electrons there. The electrodes **3** to **7** impress the electrons electronically optically in a known manner upon the semi-conducting plate **8.** The plate is provided upon both surfaces with strip contacts separated from each other, as electrodes. The electrodes **16** directed to the cathode constitute in the semi-conductor of the described type surface lock layer counters and consist of steamed on gold. The strips **17** directed to the outlet window **9,** the direction of which is changed by 90° relatively to the strips **16,** consist of steamed on aluminum. The semi-conducting plate in the illustrated example consists of n-type silicon, has a thickness of 300 μ and a diameter of about 30 mm.; it dissolves the electron spot released by the rays **15** and produced by image magnifying electron optics into individual strips which are shown sectionwise in FIG. **2** and which form electron hole pairs collected for localizing. The intersections of electrode strips **16** and **17** struck by the electron spot operate then as surface lock layer detectors similar to counter diodes.

The determination of the striking location of the electron spot or of its center takes place in the gamma cameras in a manner known per se by analog core formation. For clearer representation FIG. **3** shows only some of the electrode strips **16** and **17** which are actually present in this embodiment; they are connected by high ohmic resistances **16'** and **17'** with the coresponding d.c. voltage source **34.** As indicated in FIG. **3,** in the strips **18** and **22** (corresponding to **16**) and in the transversely extending electrode strips **23** to **27** (corresponding to **17**) are collected electron hole pairs produced by the electron bundle penetrating into the spot **45;** they are amplified in the charge-sensitive preamplifiers **18'** to **22'** and **23'** to **27'** to signals which can be further treated. The signals X_i which refer to the *i*-strips **18** to **22** and the amount of which corresponds to the part of charge carriers from the electron spot **45** collected on one side, are measured in the coordinate circuit **28** corresponding to the location of the corresponding electrode strip, *i* being the number of the continued counting of strips and *x* and the *x*-coordinate. For the measurment the signal x_i is impressed by a factor a_i with the use of a voltage divider from the resistances **35** to **44.** By a suitable selection of resistances **35** to **44** the measuring factors a_i constitute discrete coordinate values of the corresponding strips *i* in the *x*-direction. For this suitably selected resistances are used which produce voltage dividers, the ratio of which corresponds to a_i and is i/i_{max}. There *i* is the running number and i_{max} the largest available number of strips. Furthermore, the sums of the two resistances of each voltage divider are equal.

The examined signals $a_i\ x_i$ are summed up in a sum magnifier **29.** Then a signal $\Sigma\ a_i\ x_i$ is produced from which by division in the quotient forming device **31** through the sum signal of all unexamined signals x_i produced in the sum magnifier **30** the following standarized local signal is produced:

$$X = \Sigma\ a_i\ x_i / \Sigma\ x_i$$

The X signal and Y signal produced in the corresponding manner by the use of rear surface contact strips **25** to **27** in the coordinate circuit **33** (identical to **28**) are applied in this embodiment to the imaging element **32** of an XY oscilloscope and are light tested with a Z signal which is produced by impulse height discrimination of the unexamined sum signal $\Sigma\ x_i$ in one channel discriminator **46.** Then the core point of the spot **45** of the electron bundle striking the semi-conducting plate is represented in the XY diagram of the element **32.** Due to the formation of electrons indicated in FIG. **1** it corresponds to the place of the original absorption location of a gamma quantum of the energy in the scintillation crystal **14** determined by the discriminator **46,** so that the desired visible representation is attained.

What is claimed is:

1. A device for representing organs marked by gamma rays, comprising in combination a semi-conducting plate, electrode strips located on both sides of the plate and extending parallel to each other, the direction of the strips on one side extending at an angle to the direction of strips on the other side, means connected with said plate for changing the gamma quanta into electron bundles, a device connected with said plate for producing signals corresponding to gamma ray images, said device comprising calculating means for forming signals which correspond to core points of electron spots on said semi-conducting plate, and a device for treating the last-mentioned signals and actuating visualizing means.

2. A device in accordance with claim 1, wherein the semi-conducting plate located in said image magnifier has a number of electrode strips adapted to the required localizing, whereby at least three pairs of strips are used for localizing an electron bundle produced for the absorption of a gamma quantum.

3. A device in accordance with claim 2, wherein the number of electrodes carried by the semi-conducting plate ranges from 10 to 140.

4. A device in accordance with claim 1, wherein the device for core formation includes a digital calculator.

5. A device in accorance with claim 1, wherein the device for core formation includes an imaging element and an impulse discriminator located in the path of the representable signal directed to said imaging element.

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