United States Patent

Miyazawa et al.

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[54] **METHOD OF SUPERIMPOSING THE RADIATION EMISSION FROM A RADIOACTIVE TRACER ON AN X-RAY IMAGE**

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[21] Appl. No.: **812,688**

[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.**.....**250/65 R,** 250/71.5 S
[51] **Int. Cl.**.....**G03b 41/16**
[58] **Field of Search**.....250/65, 71.5 S

[56] **References Cited**

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[57] **ABSTRACT**

A system for taking a radiograph of a foreground subject in which a radioactive material is distributed on a film by an X-ray radiographic apparatus having a spark chamber. The radiograph consists of an X-ray transmission image of said subject and a discharge image indicating the distribution of said radioactive material. Said both images have the same scale and are superposed on each other.

2 Claims, 11 Drawing Figures

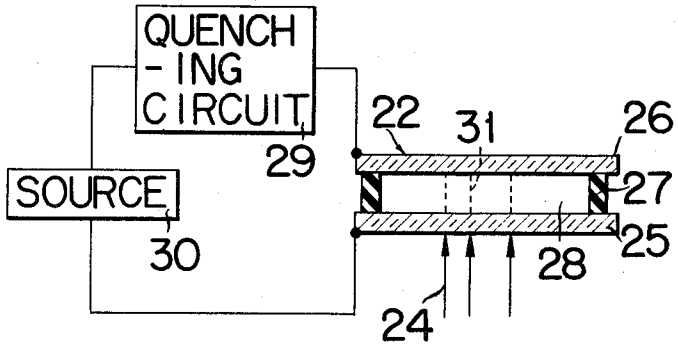


FIG. 1

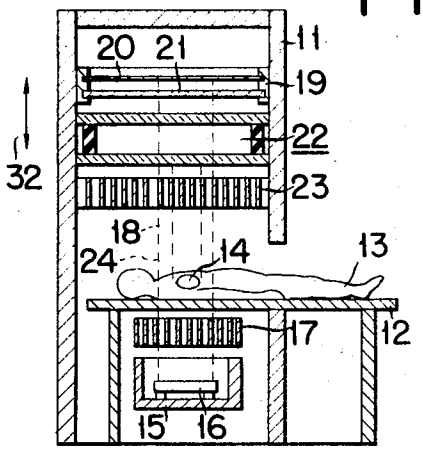


FIG. 2

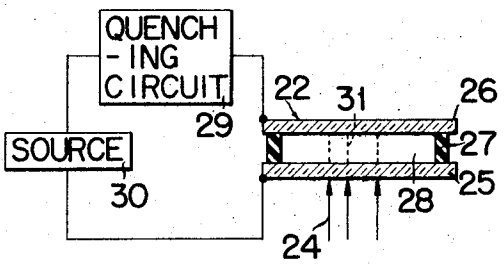


FIG. 3

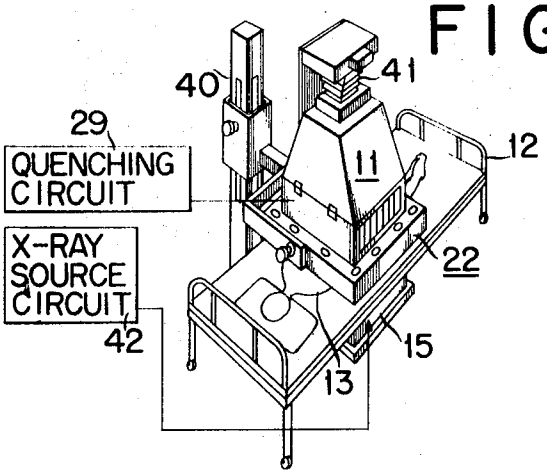
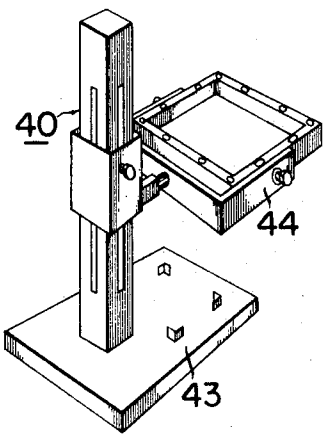


FIG. 4



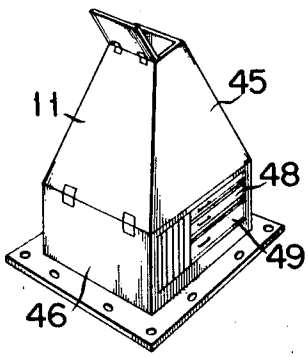


FIG. 5

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FIG. 6

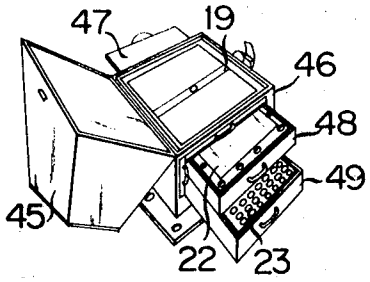


FIG. 7

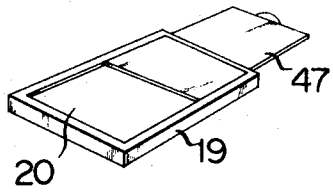


FIG. 8

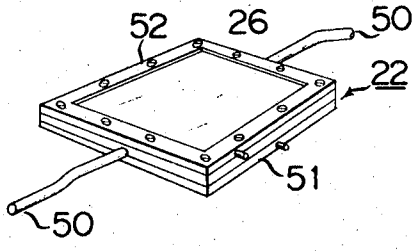


FIG. 9

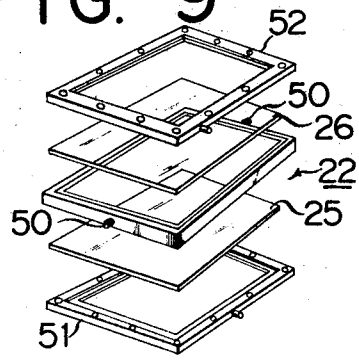


FIG. 10

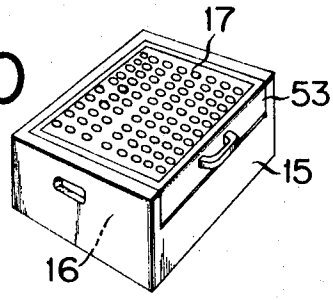
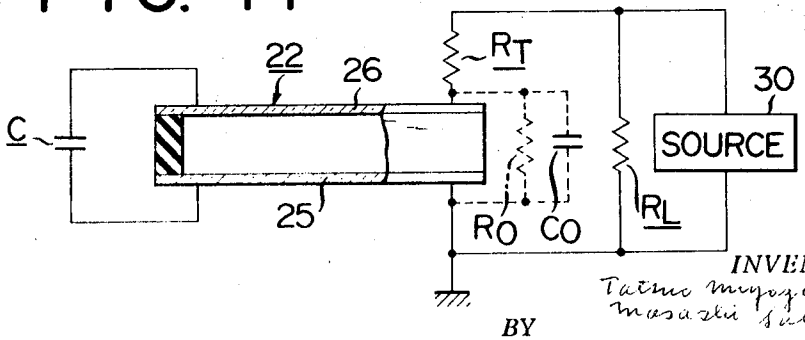


FIG. 11



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METHOD OF SUPERIMPOSING THE RADIATION EMISSION FROM A RADIOACTIVE TRACER ON AN X-RAY IMAGE

The present invention relates to radiographic methods and apparatus and more particularly to methods and apparatus for taking a radiograph of a foreground subject in which there is distributed a radioisotope.

In the medical field, there is generally practiced a diagnostic method which consists in introducing a minute amount of a specific radioisotope into a living body by means of, for example, intravenous injection or oral intake, and detecting the abnormal or affected tissues of the specific parts, for example, internal organs of a living body, utilizing the nature of such radioisotope of selectively gathering in any particular affected area. The aforementioned use of a radioisotope are required to define exactly what part of a given internal organ has actually failed. Heretofore, however, the position of the internal organ could only be inferred from the particular bone structure related to said organ. Since the size of the organ or the relative position of said organ and associated bone structure varies with individuals, the prior method failed accurately to locate the site of the organ, or clearly to find what part of the organ became diseased.

The present invention provides a method for eliminating the aforementioned drawbacks encountered with the conventional radioisotope diagnostic process and unfailingly disclosing the location of an affected organ, particularly what part of said organ has developed an abnormal state.

The method of the present invention enables the image of a diseased organ itself (or the image of its neighboring part if it is impossible fully to obtain the image of the entire organ) and also the image of the affected part of said organ (namely, an image indicating the distribution of a radioisotope applied) to be obtained, in a state superposed in the same size, using an X-ray radiographic apparatus and a device involving a spark chamber.

Insofar as the present invention is concerned, where it is impossible to obtain an image covering the whole of a given organ as is the case with, for example, a living body whose tissues are permeable to X-rays, the outline of the organ under consideration, if defined substantially clearly by the image of its neighboring bone structure, for example, may be deemed as an X-ray transmission image of a foreground subject.

This invention can be more fully understood from the following detailed description when taken in connection with the accompanying drawings, in which:

FIG. 1 is a schematic cross section of an apparatus of the present invention shown for the better understanding of the principle of the invention and said apparatus;

FIG. 2 is a schematic diagram of a circuit for actuating a spark chamber involved in the present apparatus;

FIG. 3 is a perspective view of the scene where a patient is actually photographed using an X-ray image pickup apparatus according to an embodiment of the invention;

FIGS. 4 to 10 are enlarged views of the various elements of the image pickup apparatus of FIG. 3. FIG. 4 is a perspective view of a support stand; FIG. 5 is a perspective view of a camera obscura; FIG. 6 is a perspective view of the various parts of the camera obscura shown in FIG. 5 where they are opened; FIG. 7 is a perspective view of an assembly of an X-ray photographic film and a cassette for holding said film; FIG. 8 is a perspective view of a spark chamber; FIG. 9 is a perspective view of the spark chamber of FIG. 8 when dismembered; and FIG. 10 is a perspective view of an assembly of an X-ray generator and collimator; and

FIG. 11 is a quenching circuit for actuating the spark chamber of the image pickup apparatus.

There will now be described an embodiment of the present invention by reference to FIG. 1. Numeral of reference 11 denotes a camera obscura or dark box made of radiation shielding material such as lead, numeral 12 a bed, 13 a human body, and 14 a foreground subject i.e., a portion of the body on which medical information is desired such as an internal organ like a liver. Now let it be assumed that there is selectively accumulated in the particular effected tissue of the liver 14 a minute amount of a specified radioisotope, for example, Au-198 which was injected as a tracer into the human body 13 through the blood vessels. Numeral 15 is a housing made of X-ray shielding material, such as lead which contains an X-ray generator 16, for example, an X-ray tube. Numeral 17 is an X-ray collimator taking out X-rays 18 emitted in a prescribed direction, which consists of, for example, a lead plate perforated with a large number of through holes arranged in the same direction. Numeral 19 is a cassette for holding an X-ray film 20 and exposure shutter 21. Between the foreground subject 14 and cassette 19 is detachably fitted the later described spark chamber 22. Between the foreground subject 14 and spark chamber 22 is detachably positioned another collimator 23 having substantially the same construction as the first mentioned collimator 17. The collimator 23 is used in taking out those rays 24 of radiation, for example, gamma rays emitted by the radioisotope Au-198 distributed in the foreground subject 14, which travel in a prescribed direction, namely, parallel to the aforementioned X-rays 18.

As shown in FIG. 2, the spark chamber 22 comprises a first electrode 25 prepared from a transparent conductive plate member, for example, Nesa glass which consists of a glass plate and a thin film of tin oxide coated on one surface thereof, or a metal plate readily emitting secondary electrons when bombarded by radiation and a second transparent conductive electrode 26 electrically insulated by an insulating wall 27 formed of, for example, Teflon or bakelite, thus forming a discharge chamber 28. In this discharge chamber 28 is filled inert gas such as helium, neon or a mixture thereof. Across both electrodes 25 and 26 of the spark chamber 22 is connected a DC source 30 through a quenching circuit 29. When radiation 24 is introduced into the spark chamber from the side of the first electrode 25 thereof, the electrons released from said electrode 25 or those generated by ionization of the filled gas, are accelerated by the electrical field defined by both electrodes 25 and 26, with the resultant occurrence of columnar discharges 31. To describe more concretely, when the space between both electrodes 25 and 26 is 5 mm., the potential difference is 1.6 kv. and the quenching circuit has a resistance of 10 to 20 MΩ, then the aforesaid column of discharges is 0.2 to 1.0 mm. in diameter. The columnar discharges have a density distribution corresponding to that of the incoming radiation flux, so that if light beams from the columnar discharges are accumulated at a specified part for a prescribed length of time, then it will be possible to observe from the side of the second electrode 26 the distribution of radiation in the foreground subject 14.

There will now be described the case of taking an X-ray radiograph of a foreground subject 14 using the aforementioned radiographic apparatus. First, the spark chamber 22 and collimator 23 are removed from the apparatus. Then X-rays are released from the X-ray generator 16, and allowed to be transmitted through the foreground subject 14 via the collimator 17 to record the life-size image of the foreground subject 14 on the film 20. (At this time, the shutter 21 is of course opened.) With the foreground subject 14 and film 20 kept in situ (in this case, they may be shifted in the direction of the arrow 32 of FIG. 1 in their relative position within a range of about 20 cm.), the spark chamber 22 and collimator 23 are set in place as illustrated. When the spark chamber 22 is actuated, namely, when there is impressed a prescribed potential difference across the electrodes 25 and 26, then only those rays of the radiations released from the foreground subject 14 which travel in a prescribed direction, namely, parallel to the X-rays 18 are introduced into the spark chamber 22. Accordingly on the upper electrode 26 is formed the life-size discharge image of the foreground subject 14 in accordance with the distribution of a radioisotope therein. Then the shutter 21 is operated to cause the discharge image to be superposed on the X-ray image of the foreground subject 14 previously recorded in the film 20.

The sequential steps of the aforementioned procedure may be reversed in the order, namely, the radiographing of a discharge image may precede that of an X-ray image. Or the radiographing of these images may be performed at the same time. In the case of simultaneous radiographing it may be advisable, for example, to coat the surface of the first electrode **25** of the spark chamber **22** with a material such as a film of lead capable of suitably attenuating incoming X-rays or to select such material or thickness of both electrodes **25** and **26** as to allow adequate amounts of incoming X-rays to be transmitted therethrough.

As mentioned above, the present invention enables an X-ray transmission image indicating the outline of a foreground subject and a discharge image presenting the distribution of a radioisotope in the foreground subject such as I-125, I-131, Tc-99m, Au-198, Cr-51, Hg-203, Hg-197 or Cs-131 to be superposed in the ratio of 1:1. Accordingly, the present invention will render prominent contributions not only to the aforementioned medical field, but also in industrial applications such as non-destructive testing.

Further the present invention allows X-ray image and discharge image proportioned in the ratio of 1:1 to be observed either directly by the naked eye, or by means of a camera, instead of recording them in a single film.

To do this, an X-ray transmission image is first picked up in a film held in a cassette. After being developed, the film is put back to its original position in the pickup apparatus. Next the spark chamber is actuated to cause the discharge image to be projected on the developed film. The images thus superposed are observed from above by the naked eye. If, in this case, there is set a camera above the film, these superposed images may, of course, be photographed.

There will now be concretely described by reference to FIGS. **3** to **10** an apparatus used in the image picking up method according to the present invention. The same parts of these figures as those of FIG. **1** are denoted by the same numerals.

FIG. **3** is a schematic perspective view of the scene where a patient is diagnosed by the present apparatus. Numeral **40** denotes a support pole capable of allowing a camera obscura or dark box **11** to be vertically moved. Numeral **41** is a camera, and **42** is a circuit connected to an X-ray source to generate X-rays. As shown in FIG. **4**, the support pole **40** is fixed at the bottom end to a support base **43**. On the support base **43** is mounted a housing **15** accommodating the X-ray source **16** (FIG. **10**). At the intermediate position of the support pole **40** is fitted a holding frame **44**, on which there is mounted the camera obscura **11**. As shown in FIG. **5**, the dark box **11** is allowed freely to open at the top end face. This opening enables the film placed therein to be observed by the naked eye or photographed. The camera obscura **11** is further made separable into two upper and lower parts **45** and **46** as shown in FIG. **6**. Above the lower part **46** is placed a cassette **19** to hold the film. Into the cassette **19** are detachably fitted the X-ray film **20** and exposure shutter **47** (FIG. **7**). At the lower part **46** of the box **11** are provided two drawers **48** and **49** one atop another. The upper drawer **48** holds the spark chamber **22** and the lower drawer **49** receives the collimator **23**. In front of the part of the box **11** containing these drawers **48** and **49** is set a light shade so as to prevent external light from entering the camera at this part. To the bottom of the container **45** is fitted a flange perforated with screw holes so as to fix the container by screwing the flange to the aforesaid holding frame **44**.

The first and second electrodes **25** and **26** of the spark chamber (FIGS. **8** and **9**) consist of a transparent glass plate bearing Nesa coating. Between the electrodes **25** and **26** is interposed a frame **27** made of insulating material, part of said frame being provided with inert gas outlets. Outside of the electrodes **25** and **26** are disposed outer frames **51** and **52** respectively, which are screwed together to assemble the spark chamber **22** as shown in FIG. **8**.

FIG. **10** presents the housing **15** containing the X-ray source **16** and collimator **17**. The collimator **17** consists of a lead plate of a prescribed width perforated with a large number of through holes and is detachably fitted with respect to the housing **15** because it is received in the drawer **53**. The housing **15** is formed of X-ray impermeable material, for example, lead. The X-ray source **16** contained therein may consist of a broad X-ray tube, or a plurality of ordinary X-ray tubes arranged parallel. Further, it is possible to form a slit above the X-ray tube and carry out scanning by moving the slit and X-ray tube together in a crosswise direction.

With the spark chamber involved in the image pickup apparatus of the present invention, any circuit may be usable if it is of such a type as is capable of actuating said chamber in a desired condition. For illustration, there will now be concretely described such circuit by reference to FIG. **11**. The same parts of FIG. **11** as those of the foregoing embodiment are denoted by the same numerals and description thereof is omitted. The leakage resistance and specific static capacity of the spark chamber **22** are designated by R_0 and C_0 respectively. Between the electrodes **25** and **26** is connected a condenser C whose capacity C is so defined as to have a relationship of $C>>C_0$ with respect to the specific static capacity C_0 of the spark chamber. There is serially connected an AC or DC source **30** through a resistor R_T between the electrodes **25** and **26**, the first electrode **25** being grounded. Parallel to said source **30** is connected a stabilizing resistor R_L. For illustration, when there was used a spark chamber of $C_0 = 2 \times 10^{-10} F$ and $R_L = 3\ M\Omega$, then there resulted $R_T = 20\ M\Omega$ and $C = 5 \times 10^{-10} F$.

What we claim is:

1. A method of taking a radiograph of a portion of a body comprising the steps of accumulating a radioactive tracer in a section of said body portion, placing X-ray film in a position enabling it to be responsive to radiation emanating from the body portion, directing a collimated beam of X-rays through the body portion onto the film, whereby an X-ray image of the body portion is formed on the film, collimating energy from the accumulated radioactive tracer into collimated rays directed parallel to and in the same direction as the collimated X-rays directed onto the film, placing a gaseous spark discharge chamber between the film and body in the path of the collimated rays from the radioactive tracer, whereby columnar light rays are derived from the spark chamber in accordance with the distribution of radioactive tracer in the body portion, exposing the film to the columnar light rays with the film in the same position as when the X-ray image is formed thereon, whereby the light ray and X-ray images are superimposed on the film with the same scale, developing the film prior to exposing it to the columnar light rays, then exposing the developed film to the columnar light rays, and observing the developed film while it is exposed to the columnar light rays.

2. The method of claim **1** further including the step of photographing the developed film while it is exposed to the columnar light rays.

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