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(72) Inventor GODFREY NEWBOLD HOUNSFIELD

(54) IMPROVEMENTS IN OR RELATING TO RADIOGRAPHY

(71) We, EMI LIMITED, a British company, of Blyth Road, Hayes, Middlesex, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to radiography.

In the specification of our British Patent No. 1,283,915 there is described and claimed a method of, and apparatus for, investigating a body by means of radiation such as X- or γ-radiation. The use of the said method and apparatus enables the production of a representation of a two-dimensional "slice" effectively taken through the body in a plane defined by a plurality of sets of rays directed through the body from a source of such radiation toward detector means disposed at the side of the body remote from the source; the source and the detector means being orbited around the body so as to expose said body to radiation from a plurality of different angular positions around the body.

The representation consists of a matrix of absorption or transmission coefficients appropriate to the elements of a two-dimensional matrix of elements notionally delineated in the aforementioned plane of the body. If the plane contains a member which moves, however, the motion of the member can cause localised blurring of the representation.

In accordance with the invention there is provided apparatus for examining a living body by means of penetrating radiation, such as X- or γ-radiation, including means defining a patient position, source means for projecting said radiation across a cross-sectional slice of said body along at least one beam path, said slice intersecting or lying adjacent the heart of the body under examination, means for scanning said source means relative to the patient position so as to cause said source means to project said radiation through said slice, along further beam paths, from a plurality of different locations relative to the patient position, detecting means for detecting the radiation emergent from said slice along each of said beam paths, to provide output signals indicative of the absorption suffered by said radiation on traversing said paths, processing means, connected to said detecting means, to receive said output signals and to derive therefrom a representation of the variation of absorption or transmission of said radiation over said slice, means for deriving motion signals related to the motion of the heart of the body under examination, and means responsive to said motion signals to cause said representation to be derived from output signals obtained when the heart is in a desired positional state.

In order that the invention may be clearly understood and readily carried into effect, one embodiment thereof will now be described with reference to the drawings accompanying the Provisional Specification of which:—

Figure 1 shows, in schematic plan view and part block diagrammatic form, one example of apparatus in accordance with the present invention, and

Figure 2 shows waveforms explanatory of the operation of the apparatus shown in Figure 1.

Referring now to the drawings, a body 1 to be examined is surrounded with water 2 which is maintained in a reservoir 3 formed of a plastics material substantially transparent to the radiation produced by a source 4. The body 1 is enclosed in a sheath 5 of flexible, waterproof material such as rubber so as to protect the body from the water. The source 4 produces a sectoral, planar swath of radiation 4^1, and the source and a bank 6 of radiation detectors such as scintillator crystals are mounted on an annular turntable member 7 which is rotatable by means of a variable speed electric motor 8. The motor 8 drives a gear wheel 9 which cooperates with gear teeth provided all around the periphery of the member 7.

Each of the scintillator crystals in the bank 6 is provided with a collimator (not shown) to define the path through the body which

radiation incident on the particular crystal has taken. The crystals are such as to provide a light output indicative of the amount of radiation received thereby and the light output of each crystal is fed via a respective light pipe (not shown) to a respective photomultiplier (not shown). The electrical signal produced by the photomultipliers in response to the radiation incident on the various detectors are processed, for example as described in the aforementioned patent specification, in order to produce a representation of the plane of the body which is irradiated by the source 4.

In the event that the said plane of the body intersects the heart, for example, of the patient, an electrocardiagram (e.c.g.) is taken of the patient just prior to the radiographic examination by means of a monitoring and processing circuit 10.

The e.c.g. is typically of the form shown in Figure 2(a), with each heartbeat being followed by a period of relatively little movement. A threshold is indicated by the horizontal dashed line in Figure 2 and the e.c.g. is processed in a computing circuit 11 to derive an operating waveform of the form shown in Figure 2(b) for application to the source 4.

The source 4 conveniently comprises an X-ray tube, for example a rotating anode tube, and the waveform of Figure 2(b) is adjusted to a suitable amplitude and applied to a suppressor grid electrode of the tube so as to inhibit the emission of X-rays each time the amplitude of the heartbeat motion exceeds the aforementioned threshold.

In an alternative technique, the waveform of Figure 2(b) is applied, suitably modified in shape and amplitude to a deflection coil arrangement (not shown) associated with the tube. In this case the arrangement is such as to cause the electron beam of the tube to be deflected so that it does not strike the anode of the tube each time the heartbeat motion exceeds the threshold.

It will be appreciated that the waveform of Figure 2(b) need not be used to control the actual emission of radiation by the source 4. Instead, the source 4 could be arranged to emit radiation continuously and a shutter, opaque to said radiation, could be operated in response to the e.c.g. waveform so as to intercept the radiation emitted by the source 4 during the "OFF" periods.

The circuit 11 is also effective to compute the rotational speed for the member 7 which is necessary to ensure that "ON" periods of the radiation source occur, on the or a subsequent rotation of member 7, at angular positions such as α—β (Figure 2(c)) from which the body was not irradiated during the first revolution of member 7. This is achieved via a speed control circuit 12 which responds to the computed rotational speed to actuate the motor 8 accordingly. As can be seen from Figure 2(c), the speed of the member 7 is adjusted so that, on the second revolution of member 7, the source 4 is rendered active during the traversal of the angular region α—β throughout which region the source was inactive during the first revolution of member 7.

In some circumstances it may not be possible to arrange that the source 4 is rendered active over regions such as α—β on the second scan, and in such circumstances the speed of the motor 8 is controlled to ensure that the source 4 is rendered active during the region α—β in the least practicable number of revolutions.

Overlapping information, i.e. information derived from the same angular region during successive scans, can be discarded. Alternatively, instead of obtaining such information and discarding it, the source 4 may be rendered inactive during periods in which it would produce superfluous information.

The monitoring circuit 10 may be maintained in use during the operation of the scanning apparatus so thtat fluctuations in the heartbeat of the patient during his examination can be detected and compensated for.

As a further alternative, the radiation source 4 need not be rendered inactive when the heart is not stationary. Instead the apparatus may be caused to execute several revolutions around the patient, whilst the patient's heart is monitored by the circuit 10. All the information from the scanning apparatus and the circuit 10 is then correlated in the computer 11 and any unwanted information (i.e. that obtained when the heart's motion exceeded the threshold level) is rejected. It is still advantageous, however, to monitor the patient's heartbeat rate prior to the examination so that the speed of the motor 8 can be adjusted to a suitable initial value.

WHAT WE CLAIM IS:—

1. Apparatus for examining a living body by means of penetrating radiation, such as X- or γ-radiation, including means defining a patient position, source means for projecting said radiation across a cross-sectional slice of said body along at least one beam path, said slice intersecting or lying adjacent the heart of the body under examination, means for scanning said source means relative to the patient position so as to cause said source means to project said radiation through said slice, along further beam paths, from a plurality of different locations relative to the patient position, detecting means for detecting the radiation emergent from said slice along each of said beam paths, to provide output signals indicative of the absorption suffered by said radiation on travers-

radiation incident on the particular crystal has taken. The crystals are such as to provide a light output indicative of the amount of radiation received thereby and the light output of each crystal is fed via a respective light pipe (not shown) to a respective photomultiplier (not shown). The electrical signal produced by the photomultipliers in response to the radiation incident on the various detectors are processed, for example as described in the aforementioned patent specification, in order to produce a representation of the plane of the body which is irradiated by the source 4.

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ing said paths, processing means, connected to said detecting means, to receive said output signals and to derive therefrom a representation of the variation of absorption or transmission of said radiation over said slice, means for deriving motion signals related to the motion of the heart of the body under examination, and means responsive to said motion signals to cause said representation to be derived from output signals obtained when the heart is in a desired positional state.

2. Apparatus according to Claim 1 wherein said means responsive to said motion signals is effective to interrupt the provision of said output signals when the heart of said body assumes positional states other than said desired state.

3. Apparatus according to Claim 2 wherein said means responsive to said motion signals is effective to interrupt said radiation prior to the incidence of said radiation upon said body.

4. Apparatus according to Claim 3 wherein said source means comprises an X-ray tube having a suppressor grid electrode by means of which the emission of X-rays by said tube can be interrupted by said means responsive to said motion signals.

5. Apparatus according to either of Claims 2, 3 or 4 wherein said means for scanning said source means relative to the patient position is arranged to cause said source to assume again locations, relative to said position, which were assumed by the source during interruption in the provision of said output signals.

6. Apparatus according to Claim 1 wherein said means responsive to said motion signals is effective to select, from output signals derived from said detecting means with the heart of said body in different positional states, those output signals derived with the heart in said desired positional state.

7. Apparatus according to any preceding claim wherein said source means produces a substantially planar, fan-shaped swath of said radiation and said detecting means comprises a plurality of detector devices distributed in an array extending at least across the breadth of said swath.

8. Apparatus according to Claim 7 wherein said means for scanning said source means relative to said patient position causes the source means to execute a rotational scanning movement around said position, about an axis intersecting said slice.

9. Apparatus according to either of Claims 7 and 8 wherein said detecting means emulate the scanning carried out by said source means.

10. Radiographic apparatus substantially as herein described with reference to the drawing filed with the Provisional Specification.

A. B. LOGAN,
Chartered Patent Agent.

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