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(54) TOMOGRAPHIC SCANNING APPARATUS WITH IONIZATION DETECTOR MEANS

(71) We, SIEMENS AKTIENGESELLSCHAFT, a German Company of Berlin and Munich, Germany, 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 tomographic scanning apparatus with ionization detector means.

Within very recent years, a relatively enormous degree of interest has been evidenced on the part of medical diagnosticians in a field now widely known as computerized tomography. In a typical procedure utilized in computerized tomography (or CT), an X-ray source and detector means are positioned on opposite sides of the portion of the patient which is to be examined. In the prior art, these paired elements are made to transit across the body portion to be examined, while the detector means measures the X-ray absorption at the plurality of transmission paths defined during the transit process. Periodically as well, the paired source and detector means are rotated to a differing angular orientation about the body, and the transit process repeated. A very high number of absorption values may be yielded by procedures of this type, and the relatively massive amounts of data thus accumulated may be processed by a digital computer—which cross-correlates the absorption values to thereby derive absorption values for a very high number of points (typically in the thousands) within the section of the body being scanned. This point by point data may then be combined to enable reconstruction of a matrix (visual or otherwise) which constitutes an accurate depiction of the density function of the bodily section examined. The skilled diagnostician, by considering one or more of such sections, may diagnose various bodily elements such as tumours, blood clots, cysts, haemorrhages and various abnormalities, which heretofore were detectable, if at all, only by much more cumbersome and, in many instances, more hazardous (from the viewpoint of the patient) techniques.

While apparatus of the aforementioned type have therefore represented powerful diagnostic tools, and have been deemed great advances in the radiography art, apparatus heretofore designed and commercially available have suffered from many of the shortcomings incident to first generation devices. Thus, for example, it may be noted that acquisition of the raw data obtained as an incident of the discussed techniques frequently entailed an undesirably long period—which among other things subjected a patient to both inconvenience and stress. The patient's inability to remain rigid for such a lengthy period, also could lead to blurring of the image sought to be obtained.

In our copending Patent Application No. 51,223/76, (Serial No. 1,577,014) apparatus and methodology are disclosed which alleviate a number of the prior art problems, most notably including the lengthy period that has heretofore been involved in computer processing of the raw data provided by the detector means. The apparatus therein disclosed utilizes a fan beam source of radiation coupled with application of a convolution method of data reduction, with no intervening reordering of fan rays, to thereby eliminate the errors and delays in computation time which would otherwise be involved in such reordering. The radiation source and the detector means are positioned on opposite sides of the portion of the patient to be examined and these elements are made to rotate through a revolution or portion thereof while the detector means measures the radiation absorption at the plurality of transmission paths defined during the rotational process.

In tomographic scanning apparatus heretofore widely known in the art, the detector means most commonly utlized for responding to the X-ray source took the form of scintillation counters which in turn were coupled to photomultipliers for providing suitable signal output levels. Detectors of this type, however, are known to suffer from several significant deficiencies. The scintillation crystals, for example, display hysteresis effects, i.e. they retain a memory of their earlier excitation state. Further, the photomultipliers which are utilized as an adjunct of the scintillation crystals, are relatively unstable elements which requires frequent maintenance and attention, and are, in addition, relatively expensive.

While ionization detectors are well known as measuring elements for detecting radiation in X-ray or similar systems, it has not heretofore been deemed practical or appropriate to incorporate devices of this type into scanning systems of the type considered herein. This is in view of what has been deemed a necessity for relatively long path lengths in the cell elements comprising such detectors. In general, a problem of that type can presumably be overcome by providing relatively high gas pressures in the detector cells; but heretofore acceptable designs have not been forthcoming.

According to the present invention, there is provided apparatus for examining a subject by means of penetrating radiation and providing a digital output signal for use in reconstruction of a two-dimensional representation of the structure residing in a thin section taken through the subject, the apparatus comprising:

an assembly rotatable about an axis extending along a central opening defined therein;

means for positioning the portion of the subject to be examined within the said central opening, whereby the said axis of assembly rotation is substantially perpendicular to the said section;

a source of penetrating radiation mounted on the said assembly toward one side thereof and providing radiation in the form of a fan beam;

detector means for said radiation, positioned on the said assembly opposite the said source, for detecting radiation progressing laterally across the said section and not absorbed by the subject, the said detector means comprising a gas-pressurized chamber including an array of side-by-side elongate ionization detection cells, the principal axis of each of the said cells being oriented along a radius extending toward the said radiation source, and connection means for applying potentials across the said cells and for taking output signals therefrom;

means for rotating the said assembly whereby the said fan beam impinges upon the subject at a plurality of incident directions;

signal processing and conditioning means, for receiving output signals from the said detector means and amplifying and converting these signals to digital form; and

interconnection means for receiving outputs from the said signal processing and conditioning means and enabling interfeed of the digitalized output signals to an image reconstruction station.

The apparatus could further include collimating means overlying the detector cell array, for excluding radiation from a cell of the array which is substantially off the principal axis thereof. In this case, preferably each of the said detector cells is substantially in the form of a parallelepiped, and includes a pair of spaced substantially parallel electrodes oriented with their planes transverse to the plane of the said fan beam and in the direction of the radius to the said radiation source. Such collimating means could include a plurality of mutually spaced collimating plates, each adjacent pair of these plates being substantially aligned with the pair of electrodes defining the underlying detector cell.

Preferably, said gas-pressurized chamber includes a plurality of alternating and mutually spaced high voltage elctrodes and detector electrodes, a pair of the said spaced detector and high voltage electrodes defining one of the said detector cells.

The said signal processing and conditioning means could be mounted on the said assembly and movable therewith.

The invention will now be described, by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is an external perspective view, somewhat schematic in nature, of scanning apparatus;

FIG. 2 is a perspective view, again somewhat schematic in nature, depicting a rotatable assembly portion of the FIG. 1 apparatus;

FIG. 3 is a side elevational view of the apparatus of FIGS. 1 and 2, the view being partially broken away and in section;

FIG. 4 is an elevational view of a collimator-detector assembly portion of the apparatus, the view being partially broken away in order to illustrate certain interior details;

FIG. 5 is a top plan view of what is shown in FIG. 4;

FIG. 6 is a partial view, with bottom removed, of the bottom of what is shown in FIG. 4;

FIG. 7 is a right-hand end view of what is shown in FIG. 4, the view being partially sectioned along the line 7—7 in FIG. 4;

FIG. 8 is an enlargement, generally

including the portion of FIG. 7 set forth within the dotted circle 8—8;

FIG. 9 is a cross-sectional view through detector and high voltage plates of FIG. 8, the view being taken along the line 9—9 in FIG. 8;

FIG. 10 is a broken-away left-hand view of what is shown in FIG. 4, with a collimator portion thereof removed, and illustrating certain mounting features for a cell array; and

FIG. 11 is a fragmentary plan view (broken away) of what is shown in FIG. 9, and illustrates further details of the mounting arrangement.

In FIG. 1, an external perspective view is shown, the view being somewhat simplified in nature and setting forth scanning apparatus 10. This view may be considered simultaneously with the views of FIGS 2 and 3. Apparatus 10 is seen to comprise generally an external casing 12 within which a frame 14 (FIG. 3) supports a rotatable assembly 16, which assembly is better seen in FIG. 2. Scanning apparatus 10 forms part of a computerized tomography system, the remaining elements of which principally include control, image reconstruction elements, and image display elements, most of which are contained at a control and image reconstruction station. Apparatus 10 is in communication with the said station via various control lines, as schematically indicated at link 18 in FIG. 1, which is to say that digital information obtained in consequence of the scanning operations effected by apparatus 10 are furnished to such station; and the latter, in turn, provides both control information for actuating apparatus 10, as well as the various power and excitation potentials, e.g. for the radiation source, the motor, and other elements which are present in apparatus 10.

Rotatable assembly 16 includes an outer cylinder 22 of stainless steel or other metal, and is adapted to be rotated in direction 24 about its central axis 26, by means of a motor 28, a drive wheel 30 of which bears against a drive collar 32 which is secured about cylinder 22. Wheel 30 may thus include a rubber surface 34 or the like, which by virtue of its high coefficient of friction, is effective in causing non-slip rotation of cylinder 22.

By comparing FIGS. 1 and 2, it will be evident that the central opening 36 of rotatable assembly 16 serves to receive a patient 54 who is to be examined within apparatus 10.

A sleeve 38 of plastic or the like is secured to casing 12, and provides a stationary reference frame which has certain advantages, especially psychologically, for the patient who is positioned within opening 36.

The patient 54 during use of apparatus 10 is positioned upon a top surface 42 of a positioning bench 40, the surface 42 being movable along axis 26 so as to enable movement of the patient into the apparatus. A laser source 44 is positioned in front of apparatus 10 at an overhead position (FIG. 3) so that the beam 46 thereof impinges upon the patient at an axial location—to aid in proper alignment of the patient during the examination process. The laser may also be affixed to portions of casing 12. The bench 40 may include actuating means which enable incremental advance of the same, so as to facilitate successive transverse scan sections through the body of patient 54, and which also enables movement of the bench in other directions to facilitate patient positioning.

The forward end of assembly 16 carries a plate 48, at the periphery of which is mounted a radiation source 50—comprising an X-ray source capable of projecting an X-ray pattern in the form of a fan beam 52. Fan beam 52 is yielded by a collimator 51 which is positioned in front of the X-ray emission source—as is known in the art. Fan beam 52 is preferably (though not necessarily) at least as wide as the object to be examined, which in the present instance, of course, constitutes patient 54.

A collimator-deecor assembly generally indicated at 56, and consisting of detector means 458 and collimating means 460, is mounted directly opposite source 50, i.e. toward the opposite edge of plate 48. Detector means 458 comprises an array of ionization chambers, such as xenon or xenon-krypton detectors.

It will be seen that detector array 458 is in very close physical proximity to signal processing and conditioning means generally indicated at 64. Indeed, in the aparatus depicted these two blocks are back to back with respect to one another. This close physical proximity has important advantages in that the close proximity of these elements—which are commonly rotatable with assembly 16—minimizes the possibility of introducing spurious signals into the various detector channels. This is particularly signaficant in that the high potentials associated with the X-ray source etc. increase the likelihood of introducing such spurious signals.

The assembly 16, in addition to including the several elements thus far described, includes certain strengthening elements such as a reinforcing ring 66 and cross-braces 68. The purpose of these several elements is to increase, to the extent practical, the rigidity of the overall assembly 16, thereby decreasing the effects of vibration and the possibility of undesired flexure, all of which can be particularly detrimental with respect to the detector structures—i.e. stressing of certain of these structures can change the electrical response characteristics of the same, thereby introducing erroneous readings.

In the case of X-ray diagnosis, the thickness of fan beam 52 as defined by the collimator 51 is typically between 1mm and 15mm at the middle of the object. It will be understood that, as the source and the detector array undergo relative rotation with respect to the patient (continuously where exact reconstruction is desired) over a time of approximately 1 to 15 seconds, readings of absorbed radiation are measured by detector array 458. The data acquisition may be completed during one relative revolution (i.e. 360 degrees) of the system, although the present system is also well adapted to acquire the data over the course of several revolutions—which can provide superior images because of the increased quantity of data. As further described in copending Applications Nos. 51,223/76 (Serial No. 1,577,014) and 37591/77, (Serial No. 1,593,274) data from detector array 458, after suitable processing and conditioning, is provided to the control and image reconstruction station where it is convolved, appropriately stored and later back-projected with other data to produce an output picture which is a replica of the thin cross-section of patient 54 which has been examined. It will of course be understood that the data need not be necessarily converted into a visually discernable picture, but can be expressed in other analytical forms, i.e. numerically or so forth.

As may be seen by consideration of FIG. 3, electrical interconnections to all portions of assembly 16 which require the same, are effected via a slip ring assembly (detais not shown) which is generally indicated at 70. In particular, it will be observed that high voltage input lines 72 and 74 are provided to a casing portion 76 of assembly 70, which portion is stationary. The slip ring interconnection provides the required excitation connections to X-ray source 50 via cables 78 and 80 which proceed from a casing portion 82 of assembly 70. The latter, portion 82, rotates with rotating assembly 16, which is supported on a bearing 85 between ring 66 and a frame ring 86. In particular, rotation of portion 82 is effected commonly with the cylinder 22 by means of a link 260 which is secured to portion 82 and engages a pin 262 which projects from the rearward side 264 of cylinder 22.

Similarly, the various further low voltage interconnections, i.e. for the detector outputs, for the various low voltage control signals for the electrical elements mounted on plate 48, and for the low voltage inputs to source 50 (for the anode rotor), are all enabled by means of slip ring connections contained within a portion 88 of slip ring assembly 70. Thus, several of the external connections 90 appear at portion 88. The external casing of portion 88 is, of course stationary.

Referring now to FIGS. 4 to 10, details are set forth of the collimator-detector assembly 56. Referring generally to the views of FIGS. 4 and 5, it is seen that assembly 56 consists of the detector array 458 which is separate from but maintained in fixed relationship to the overlying collimator means 460. The two are maintained in direct contact with one another, by being secured to a support plate 462—in each instance by bolting means. Mounting blocks 465 are secured to plate 462, and, in turn, enable collimator-detector assembly 56 to be secured to plate 48.

Collimating means 460 comprises a pair of collimator support members 484, 486 which are maintained in spaced relationship by spacers 464, the members being secured to plate 462 by bolts 468. The upper side of collimating means 460 is therefore generally open (except for a thin radiation-pervious covering 469 of plastic which prevents dust and debris from entering) and serves to admit the incident radiation provided by fan beam 52. As best seen in the top view of FIG. 5, a pair of parallel strips 470 and 472 extend lengthwise across the top open portion of collimating means 460 (in overlying relation to cover 469). The ends of these strips 470 and 472 are supported by a pair of brackets 474 and 476 via threaded members 478 which pass through the plates and thence into the top edges of support members 484 and 486. The openings in brackets 474 and 476 through which the fasteners pass are elongate, in consequence of which the width of the slit 480 defined between strips 470 and 472 may be adjusted. Strips 470 and 472 comprise a material which is very absorbing with respect to the incident X-ray radiation, as for example, lead, and accordingly the slit 480 serves as a collimator for the radiation beam proceeding toward the detector array 458. By adjusting the aforementioned spacing between strips 470 and 472, one can to a degree adjust the thickness of the incident fan beam 52—in order, e.g., to improve definition or so forth in the resultant X-ray image. It, of course, will be understood that equivalent techniques can be used for adjusting slit 480.

For example, a rack and gear arrangement actuated by a motor can displace strips 470 and 472 away from their centre line.

Referring to the broken-away portion of collimator means 460 in FIG. 4, a plurality of collimator plates 482 are mounted in collimating means 460 in a manner that will be further discussed below. In a typical embodiment, a total of 302 such mutually spaced collimator plates may be thus mounted. Each such plate is actually oriented so that its plane resides approximately along a radius proceeding to the X-ray source. The collimator plates 482 comprise a material which is highly absorbtive with respect to X-ray radiation, as for example, stainless steel or so forth, and such plates serve to collimate the X-ray proceeding from source 50 toward a plurality of detector cells which are provided at detector array 458. Each such detector cell is oriented so that an overlying pair of spaced collimator plates 482 will direct the radiation passing therebetween in an axial direction through the associated detector cell.

By referring to the partially sectioned view of FIG. 7, it will be seen that the collimator support members 484, 486, which may comprise a composite fibreglass material or the like, include a series of parallel channels 488 which extend lengthwise along the inside face of each of the support members. Narrower channels or slots 483 are also formed in a vertically inclined direction in the support members 484 and 486. These further slots 483 serve to accommodate particular collimator plates 482, and the specific inclination of any given vertically inclined slot 483 is such as to orient the plate inserted therein approximately along a radius to the X-ray source. The two support members 484, 486 are partially maintained in spatial relationship to one another by a dowel pin 490 which also passes into plate 462.

During fabrication, the collimator plates 482 are positioned in the vertically inclined slots 483 and an epoxy resin composition is thereafter flowed along the channels 488—which then enable such composition to flow within the vertically inclined slots 483 as well, and thereby fix (i.e. following curing) the position of the collimator plates 482.

Detector array 458 comprises a chamber 512 which is completely enclosed except where various electrical feed-throughs, gas valves or guages or so forth are provided—as hereinbelow will be set forth. Total enclosure is of course necessary, in that the detectors are of the ionization type, i.e. measurements are effected via ionization currents generated in inter-electrode gaps by the X-rays being absorbed in a high-Z gas such as xenon, krypton or a xenon-krypton mixture contained in the said gaps at relatively high pressure, typically at 10 atmospheres or more. In particular, and referring to the relatively schematic showing of FIG. 4, a series of side-by-side ionization detector cells are created by virtue of alternating high voltage plates 496 and detector plates 498. A pair of such high voltage and detector plates, i.e. defining a detector cell, is actually aligned with a pair of spaced collimator plates 482 so that, as already mentioned, the collimated X-ray radiation proceeding between a pair of adjacent collimator plates 482 thence passes directly into the associated detector cell. A total of 301 such detection cells are actually defined within detector array 458.

Referring to the right-hand side, partially broken away, view of FIG. 7, it will firstly be noted that the detectors are actually in a U-shaped shell 500 which is affixed to support plate 462 by means of a plurality of bolts 502. A sealing gasket 504 is provided adjacent the interface between member 500 and plate 462. The gasket 504 may comprise indium wire—which becomes deformed at the interface during joining of member 500 and plate 462. As seen in FIG. 5, a compression adapter 503 and vacuum valve 507, are provided, which enable gas to be introduced, as required, to the interior of the enclosure (i.e. to chamber 512); and similarly a gas pressure guage 509 is provided for enabling examination of the pressure within chamber 512. A channel 505 constituting a window for the collimated X-rays proceeding toward the detector cells, is also formed lengthwise along one side of the U-shaped shell 500.

A pair of plate support members 508 and 510 extend for most of the length of the chamber 512. The plate support members 508 and 510 comprise an electrically insulating material such as for example a composite fibre-glass material or so forth. A bolt 515, one of a pair of such bolts, and a pin 516 support members 508 and 510 in their vertical positioning. It will be noted, however, that some spacing 520 is present adjacent the outside surfaces of each of the support members 508 and 510. Resilient washers 522 may intervene in spacing 520. In addition, or in place thereof, the arrangement shown in FIGS. 10 and 11 may be employed for providing a degree of shock absorption between the support members 508, 510 and the adjacent inner metallic walls surrounding chamber 512. Thus, as seen in FIGS. 10 and 11, an extended length of tubing 514, of plastic, as for example of Teflon (Registered Trade Mark) may be passed several times about the outer lateral periphery of members 508 and 510 and spacers 464[1], with the ends of the said tubing being secured to spacers 464[1] by means of threaded fasteners 516. The purpose of the aforementioned resilient elements, i.e. tubing 514, and washers 522, is to isolate the array of detector cells from mechanical shock, which could act to affect the spacing of the cells, and thereby introduce spurious signals.

The various detector plates 498 and high voltage plates 496 are mounted in their desired positions within support members 508 and 510 by the same technique as has been described with respect to mounting of collimator plates 482. In particular, a series of channels 530 extend lengthwise along the inwardly directed faces of members 508 and 510; and, in addition, a series of vertically inclined slots 531 are formed, which intersect the channels 530. These vertically inclined slots function to receive and thereby position the detector and high voltage plates 496 or 498. Thus, of course, the said vertically inclined slots 531 make an angle with the vertical, which increases as one proceeds toward the opposed ends of support members 508 and 510, in that (as already discussed), the detector cells, like collimator plates 482, will be approximately aligned along radii proceeding toward the X-ray source. Thus, each of the said detector cells, which is essentially in a form of a parallelepiped, with have its principal axis approximately aligned along such a radius.

The structure of the detector plates 498 and high voltage plates 496 may be better understood by reference to the enlarged view of FIG. 8, and the cross sectional view of FIG. 9 which is taken along the line 9—9 in FIG. 8. Each of the high voltage plates 496 comprises a stainless steel material, typically of about .025 inches thickness. Each of the plates 496 is connected through a resistor 528 to the positive side of a high voltage source (schematically indicated at 524—and typically providing potentials of the order of 500 to 5000 volts) by a connection effected at a tab portion 526. Each such tab portion 526 is thus connected via a current limiting resistor 528 and a high voltage bus 532. Connection to high voltage bus 532, as may be seen in FIG. 7, is effected by means of an insulating connector 534, which may be of the "spark-plug" type.

Referring particularly to the cross sectional view of FIG. 9, it will be seen that each detector plate 498 is actually formed in a laminate detector structure 536, which includes a central conductive layer 538, e.g. of copper, on each side of which resides an insulating layer 540 of plastic, over each of which is a stainless steel detector plate 498. Thus, it will be clear that it is actually such a detector structure 536 which is mounted between any two high voltage plates 496—whereby any given ionization cell is defined by one of the detector plates 498 carried by such structure 536, together with a spaced high voltage plate 496.

Formed along all lateral edges of the detector plates 498, but spaced therefrom, is a guard ring 542, also of stainless steel. In practice, structure 536 shown in FIG. 9, is formed by photoetching away the portions 544, to leave the spaced guard ring 542. In use, guard ring 542 is maintained at a ground potential via a connecting tab 555 (as also schematically suggested in FIG. 9) and the signal from each individual cell is taken from the detector plate 498. The spacing between each high voltage plate 496 and the detector plate 498 associated therewith, is typically of the order of .100 inches, with the total thickness of structure 536 being only about .025 inches.

Structure 536 which includes the aforementioned guard rings 542 and central conductive layer 538, in effect thoroughly shields each detector plate 498, in a manner resembling that which occurs in a co-axial cable, i.e. a ground shield effectively envelopes the conductive signal-carrying detector plate 498. The net effect of this arrangement is to vastly reduce stray capacitance effects or cross-talk between adjacent cells. In consequence, especially in further view of the reduction in physical shock effects which is enabled by the structures previously discussed in connection with FIGS. 10 and 11, the readings provided from the various detector cells are little affected by extraneous electrical activity or by vibration or the like.

The lead-out signals proceeding from the detector plates 498 pass through lead-out wires 550, which pass through insulating sleeves 552 where required. A plurality of such lead-outs then proceed out from support plate 462 through a plurality of feed-throughs 554.

WHAT WE CLAIM IS:—

1. Apparatus for examining a subject by means of penetrating radiation and providing a digital output signal for use in reconstruction of a two-dimensional representation of the structure residing in a thin section taken through the subject, the apparatus comprising:

an assembly rotatable about an axis extending along a central opening defined therein;

means for positioning the portion of the subject to be examined within the said central opening, whereby the said axis of assembly rotation is substantially perpendicular to the said section;

a source of penetrating radiation mounted on the said assembly toward one side thereof and providing radiation in the form of a fan beam;

detector means for said radiation, positioned on the said assembly opposite the said source, for detecting radiation progressing laterally across the said section and not absorbed by the subject, the said detector means comprising a gas-pressurized chamber including an array of side-by-side elongate ionization detection cells, the principal axis of each of the said cells being oriented along a radius extending toward the said radiation source, and connection means for applying potentials across the said cells and for taking output signals therefrom;

means for rotating the said assembly whereby the said fan beam impinges upon the subject at a plurality of incident directions;

signal processing and conditioning means, for receiving output signals from the said detector means and amplifying and converting these signals to digital form; and

interconnection means for receiving outputs from the said signal processing and conditioning means and enabling interfeed of the digitalized output signals to an image reconstruction station.

2. Apparatus in accordance with claim 1, further including collimating means overlying the detector cell array, for excluding radiation from a cell of the array which is substantially off the principal axis thereof.

3. Apparatus in accordance with claim 2, wherein each of the said detector cells is substantially in the form of a parallelepiped, and includes a pair of spaced substantially parallel electrodes oriented with their planes transverse to the plane of the said fan beam and in the direction of the radius to the said radiation source.

4. Apparatus in accordance with claim 3, wherein the said collimating means includes a plurality of mutually spaced collimating plates, each adjacent pair of these plates being substantially aligned with the pair of electrodes defining the underlying detector cell.

5. Apparatus in accordance with claim 3 or 4, wherein the said gas-pressurized chamber includes a plurality of alternating and mutually spaced high voltage electrodes and detector electrodes, a pair of the said spaced detector and high voltage electrodes defining one of the said detector cells.

6. Apparatus in accordance with claim 5, wherein the said detector and high voltage electrodes are supported by a pair of spaced electrically insulating support members, the said members carrying slots formed therein for receiving and supporting the said electrodes.

7. Apparatus in accordance with claim 6, wherein the said support members are maintained in spaced relationship with respect to the interior lateral walls of the said chamber; and further including resilient shock absorbing means mounted in at least some of the interspace between the said support members and the said chamber walls, for absorbing vibration and other mechanical shock.

8. Apparatus in accordance with any of claims 5 to 7, wherein the said detector electrodes are in pairs on the opposed sides of detector electrode structures, each of which includes a central conductive layer sandwiched by first and second insulating layers, the detector electrodes being provided on the outward facing surfaces of the said insulating layers; and wherein the said detector means further includes connection means for grounding the said central conductive layers for electrically shielding the said detector electrodes to reduce generation of spurious signals.

9. Apparatus in accordance with claim 8, wherein a guard ring is formed on each of the said outward facing surfaces of the said insulating layers, the said ring surrounding but being spaced from the lateral edges of each of the detector electrodes; and wherein the said guard rings are grounded together with the said central conductive layers to increase the effectiveness of the said electrical shielding.

10. Apparatus in accordance with claim 4 or any of claims 5 to 9 as dependent upon claim 4, including collimating slit means overlying the said collimator plates, the said slit extending in a direction transverse to the said collimator plates and generally parallel to the plane of the said fan beam.

11. Apparatus in accordance with claim 10, wherein the said collimating slit means includes means for adjusting the width of the said slit.

12. Apparatus in accordance with any preceding claim, wherein the said signal processing and conditioning means is mounted on the said assembly and movable therewith.

13. Apparatus for examining a subject, substantially as herein described with reference to, and as illustrated in, the accompanying drawings.

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4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

FIG. 1

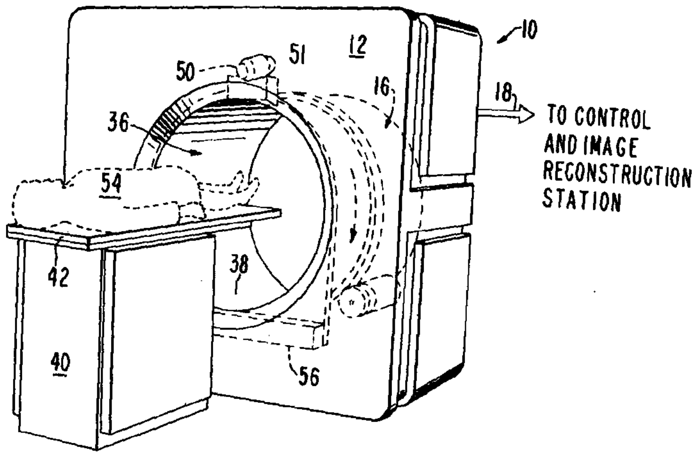
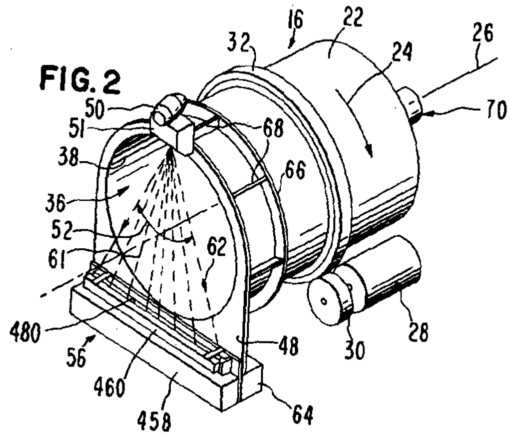


FIG. 2



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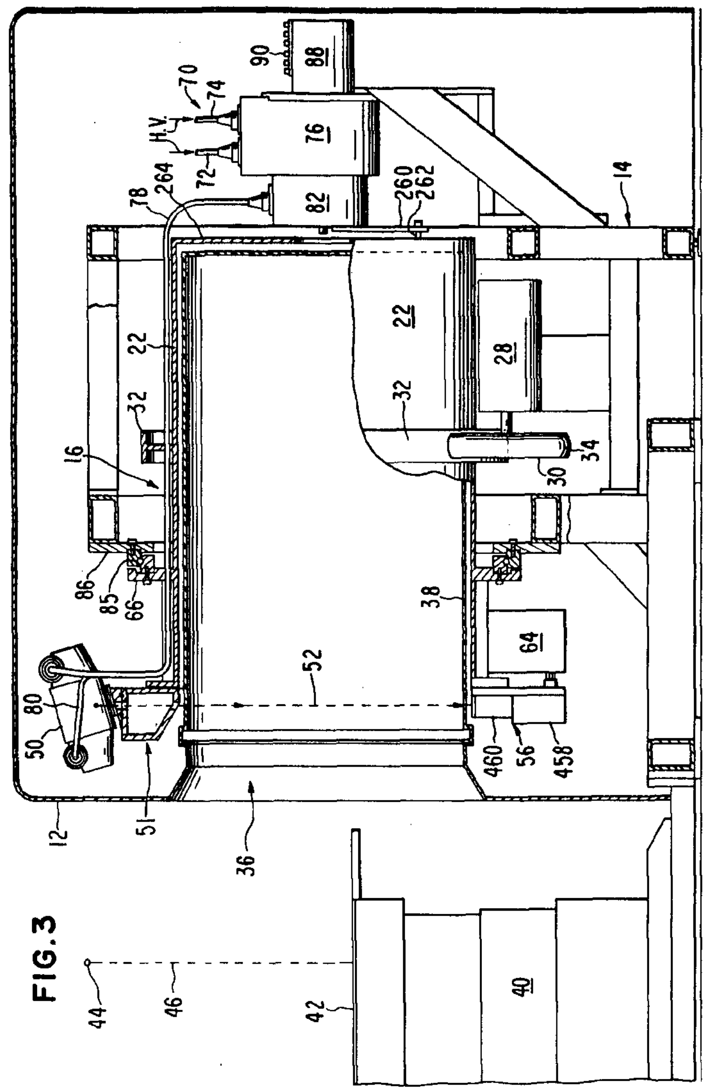

FIG.3

1594272 COMPLETE SPECIFICATION

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Sheet 3

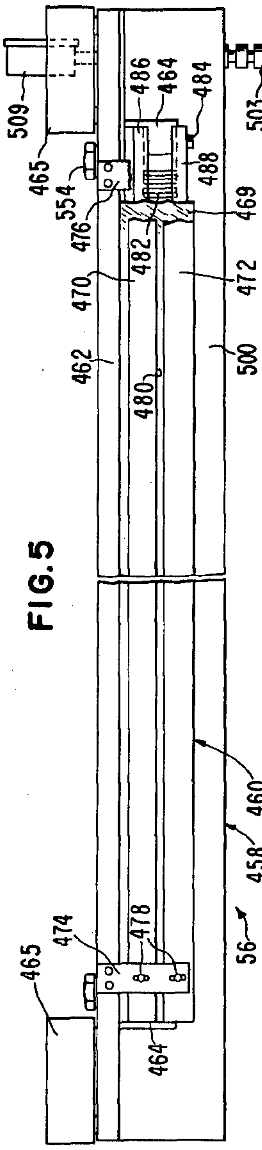

FIG.5

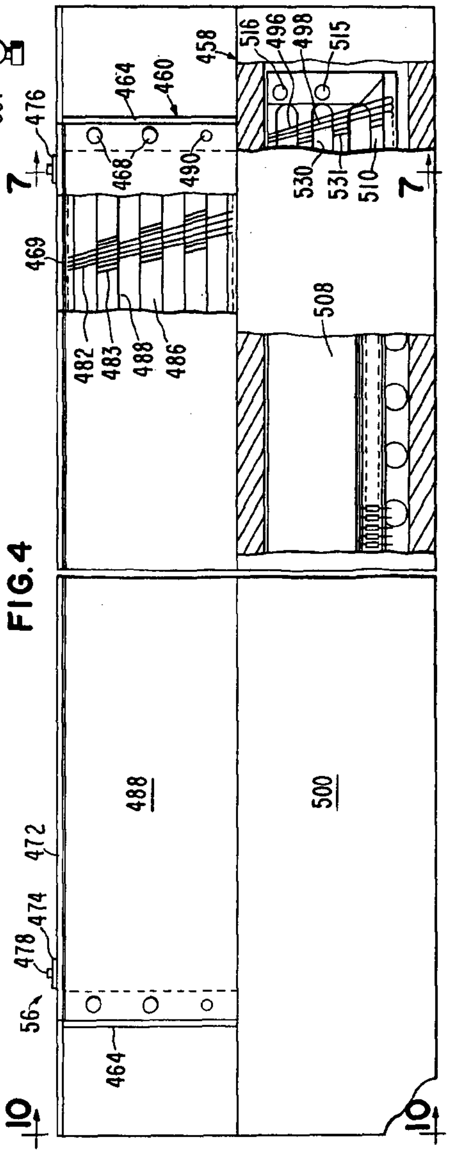

FIG.4

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Sheet 4

FIG.10

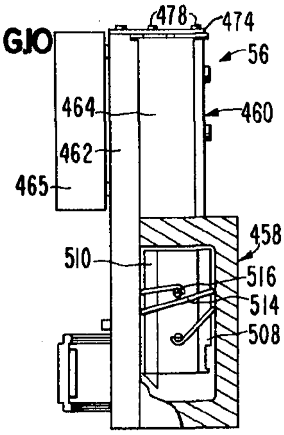


FIG.11

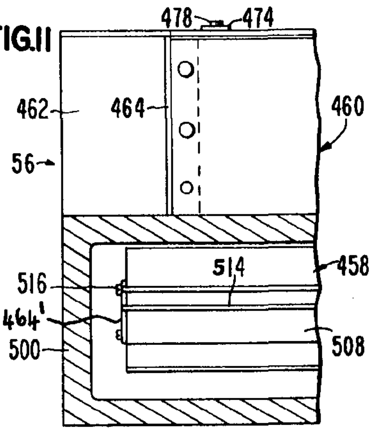
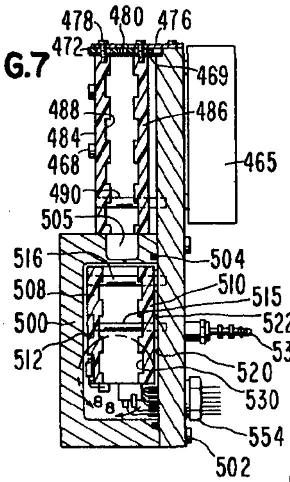


FIG.7



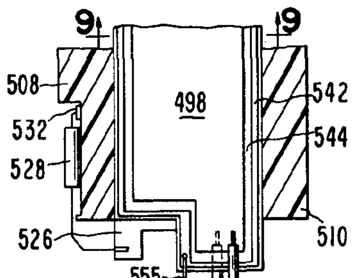


FIG.8

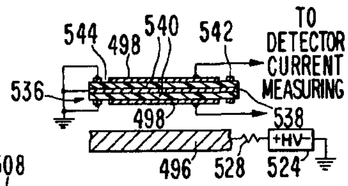


FIG.9

FIG.6